If fire is a hazard, why do some plants and animals depend on fire?

Primary: (ages 7-11)	**Science (Earth Science)**

In this unit, students consider what they know about fire and recent news about massive fires and make arguments from different perspectives about how fire can be both a hazard and a benefit to plants and animals, including humans. They observe and describe cycles of ecosystems and compare plants in those ecosystems to identify plant traits that are dependent on fire and adapted to fire. Students consider how human activity has created conditions for massive fires. They make models for how burns can be a solution to protect threatened ecosystems and to protect the animals that live there.

Time allocation	About 12 lesson periods
Subject content	Ecosystems, habitats and adaptation Fire ecology; The fire triangle; Heat, potential energy and energy transfers Carry out observations and investigations to predict change to landforms and Earth surfaces. Recognise and use patterns and relationships
Creativity and critical thinking	This unit has a **creativity** and **critical thinking** focus: • Generate and play with a variety of ideas and propose, produce, and revise a personally novel model of how land is changing. • Reflect on models based on evidence collected across the unit and consider different perspectives to explain what is causing change in different places.
Other skills	Collaboration, Communication
Key words	Adaptation, temperature, drought, restoration, life cycle, prescribed burn, habitat, ecosystems, traits., models

Products and processes to assess

Students develop their collaborative, creative, modelling skills by sharing ideas, carrying out investigations, making observations, constructing, critically evaluating and revising models, and using models and ideas to explain phenomena.

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Teaching and Learning plan

This plan suggests potential steps for implementing the activity. Teachers can introduce as many modifications as they see fit to adapt the activity to their teaching context.

Step	Duration	Teacher and student roles	Subject content	Creativity	Critical thinking
	(Prep-aratory phase)	Learn about local efforts to conduct prescribed burns, preferably in the area near the school. Find out which plants and animals are being protected through these efforts. Set up a driving question board (DQB), which is a place where students can pin or stick questions, thoughts, comments etc. they have about the driving question (the title of the unit).			
1	Lesson periods 1 and 2	**What do we already know about fire?** Students consider and describe a piece of burnt toast and a piece of untoasted bread, and the teacher explains briefly the chemical changes involved For example, the teacher could say 'Do you think these two pieces of bread are the same or different material? Give evidence for your answer. Or the teacher could ask the students to break off some of each piece to examine the matter more closely. What do you notice about parts of each? Once students have given their reasoning, and as appropriate to the context, the teacher can explain that the heat causes a new substance (compound) to be created that has a different colour and odour from the uncooked bread. (or if no toast is available, students compare two items which have and have not been physically changed by fire). Ask students what they know about fires and about fire as a tool. Introduce the Unit Driving Question (DQ) and watch videos about fires in different places (a forest, a campfire, a welder's fire, etc.). Students ask questions about fire and categorize them. They make a 'human snake' in response to the question: "Are wildfires a benefit or a hazard?" – with one side representing benefit and the other side representing hazard from definitely beneficial, somewhat beneficial, somewhat hazardous, definitely hazardous. Discuss places in line drawing on experiences and mining new and diverse perspectives as a group. The teacher explains that students will interview family members about their experiences of fire as homework, provides time for students to plan their questions and gives feedback on questions.	The chemical and physical effects of heat / fire and previous experiences and knowledge of fire.		Inquiring: Understanding the context, frame and boundaries of the role of fire.
2	Lesson period 3	**How do fires happen and keep going?** Students bring interviews and drawings of an experience with fire as an ecological or other tool, a skill, or a basis for entertainment that a family member shared with them (including candles, fireworks, cooking etc.). One by one, they present and record information from the interviews. Teachers asks questions and encourages other students to ask questions, "What was there for the fire to start?" "How did the fire	The causes, effects and necessary conditions of different kinds of fires.	Inquiring: Making connections between different	Inquiring: Identifying and questioning assumptions about fire.

		keep going?" "How did the fire stop?" "What was the fuel made up of?" How big was the fire? Why was it that size?" "How did the people involved feel about the fire?" Once the students have shared their thoughts, as needed, the teacher explains the scientific processes involved in starting, fuelling and stopping the fire (e.g. the fire triangle). Students note patterns in the interviews and any ideas they prompt, discuss differing perspectives arising in the interviews, and identify and evaluate any assumptions being made (the teacher can explain that assumptions are things that are accepted as truth without proof, if required). If time allows, the students can read or watch some interviews with fire ecologists (see resources) and discuss what additional information they provide. They discuss whether they can use the information as evidence to consider the unit's driving question and why/why not. They compare the cause and effects of large and small fires. Students add more questions to the Driving Question Board.		experiences of fire.	Evaluating knowledge developed.
3	Lesson period 4	**Are there more massive fires now than in the past?** Students review what they know about large fires. They analyse a figure that shows how many massive fires there have been in the world over the last 100 years. With the teacher posing questions and providing information as needed, the students analyse a second figure that tracks global drought in the last 100 years, and finally a third figure that looks at global temperatures in the last 100 years. They make two different claims for each graph and look for patterns across all the data sources. The teacher leads a discussion, "Why might there be more massive fires now than in the past?" The teacher presses students for reasoning, they do not have to have a "correct answer," just sound reasoning. They also ask students to consider what different perspectives might be possible on these claims and what assumptions they involve. Check the Driving Question Board to see if any questions have been answered and to add any additional questions or comments.	Using graphs and mathematical thinking to analyse patterns in data regarding global drought, temperatures and fires.	Inquiring: Making connections, considering patterns in data.	Imagining: Considering alternative theories, opinions, assumptions and perspectives on a problem.
4	Lesson period 5	**What do all fires need?** Students are introduced or reminded of the fire triangle that shows fires need three ingredients to start and be sustained: Heat, fuel, and oxygen. They are asked to consider how they might conduct an investigation about heat being one necessary condition for fire. The teacher encourages novel and unusual ideas and accepts all ideas initially, before leading the class in examining the ideas for their strengths and limitations as a way to address the question. The teacher leads the investigation, as described by one or more students, and has safety equipment in hand. For example, S/he might put frozen and room temperature fuel/paper/candle/wood in two jars and	The fire triangle. Investigating the relationship between heat and fire using familiar materials.	Imagining: Stretching and playing with unusual ideas for planning an investigation.	Doing: Explaining strengths and limits of ideas for an investigation, according to different criteria.

		then have a student time how long each takes to ignite and burn. Exit Slip: If heat, oxygen, or fuel were removed from a fire, what would happen to the fire? Why?			
5	Lesson periods 6 and 7	**How are plant structures adapted to fire?** Students examine a cone from a spruce tree, and the teacher shows a time-lapse video of how the cones open with fire and explains some basic information about fire adaptive traits and how they have evolved over time. Students go on a scavenger hunt outside. They look for plants that have possible adaptations to fire. The teacher presses students for reasoning, and accepts ideas with sound reasoning (i.e., thick bark is an adaptation to fire; long roots are an adaptation to fire; high branches are an adaptation to fire). Students check the DQ board to see if any questions have been answered and to add any new questions.	Fire adaptive traits; Using observations to collect evidence of plant structures that may be adaptive to fire.	Imagining: Stretching and playing with unusual ideas about possible adaptations to fire.	
6	Lesson periods 8 and 9	**How damaging is fire?** Students view a time-lapse video of a forest after a fire. They are shown six photos that represent an ecological cycle of the area (see resources). Students first describe the pictures, and then they order them chronologically. Students use the evidence from steps 2, 3, 4, 5 and 6 to generate, discuss, and improve claims about fires. For example, they might claim all or some of the following: That fires must have specific conditions to start and continue, that some fires are useful, some fires cause irreversible changes to objects and places, and some fires create new spaces for plants to grow. The teacher prompts them to identify any assumptions they are making and consider whether alternative perspectives might be possible. The teacher replays the time-lapse video to underscore the idea that without this fire, the forest would not have been restored to healthy grassland. The teacher offers some basic information about the biology of native ecosystems and what plants and trees need in order to grow (light, air, water, nutrients). Students help create a shared model that shows that ecosystems have a natural cycle that can include fire for restoration of habitat (or setting back succession). Finally, the teacher shows a photo of an area where there was a massive fire, and where very little biota in the soil and roots of plants survive. Students research and discuss how much more time would be needed before animals and plants would be re-established in the area after this sort of massive fire.	Ecosystems, ecological regeneration and the role of fire.	Imagining: Generating and playing with ideas for unusual and radical claims about fires and for how to model ecosystems.	Inquiring: identifying and questioning assumptions when making claims, checking accuracy of facts and interpretations, analysing gaps in knowledge on the role of fire.

		Gather more questions from students, and check previous questions to see if any have been answered.			
7	Lesson period 10	**Which animals depend on fire?** Students have learned that plants depend on (some types of) fires, and in groups they are now introduced to an animal in the local area (i.e., butterfly species, grassland birds, and mammals associated with savannah). Depending on preference the teacher can ask all students to work on the same animal or can have different groups working on different animals. The teacher reminds students about the meaning of the term habitat. The students engage in research using texts and media to develop a life cycle model of the animal to explain the parts of the life cycle that must occur in an environment that is grassland or savannah. A few students volunteer to share their model, and discuss briefly with their group 1) any difficulties they had when creating it and how they overcome those difficulties, 2) any assumptions they made and why 3) their model's strengths and limitations 4) what is novel about their models and 5) any remaining uncertainties or doubts. If there is time, they revise their models on the basis of feedback received.	Local habitats and wildlife. Gathering information from texts to model an animal's life cycle.	Doing: Drawing, sharing and revising a life cycle model, in a personally novel way.	Doing: Identifying strengths and limitations of evidence in life cycle models. Justifying reasoning for model components. Reflecting: on model relative to alternatives.
8	Lesson periods 11 and 12	**What criteria can we use to decide if fire is a benefit or a hazard?** Students work in groups to develop models that show how change in ecosystems due to small fires that restore forest to prairie, grassland, and savannah is necessary for some local plants and animals to reproduce and survive. They present their models, receiving feedback about their strengths and limitations. Next each group shows what would happen to the ecosystem in a massive fire, similar to those which have become more prevalent as temperatures and incidents of drought rise. Students are introduced to prescribed, or control burns, which are fires started by fire ecologists, that can restore targeted habitat and decrease the frequency of large-scale uncontrollable fires. They add text under their model to explain how a controlled burn could be a tool to protect plant and animal species and mitigate the problem of massive fires, as well as explaining any risks or differing perspectives. Display the models and texts in the classroom, or school. Review all of the questions on the Driving Question Board. Students propose, discuss strengths and limits, and select criteria from the previous lesson periods to help decide if a fire is a benefit or hazard. The teacher prompts them to consider what assumptions they are making, what evidence will support claims, and what alternative perspectives are possible on what criteria to use. Students recreate the human-snake where they stand in line according to whether fire	Developing and sharing models and criteria for when a fire is a benefit or a hazard. Answering remaining questions about fire.	Doing: Producing, sharing and revising models of changes to ecosystems, in a personally novel way. Reflecting: on and assessing relevance of variables.	Doing: Assessing the strengths and limitations of models and criteria for deciding on whether fires are beneficial or hazards. Reflecting: Evaluating knowledge developed, considering position relative to alternatives and acknowledging remaining uncertainties.

	is a benefit or a hazard. They write in the notebook reflecting on why they stood where they did, whether and why they changed their mind since step 1, and where they still have doubts or uncertainty and why. The teacher asks students to reflect on how they decided where to stand and whether they made any assumptions when they were making up their mind. The class discusses the difficulty of deciding where to stand in the snake because it depends on what sorts of fire and criteria you have in mind.	

Resources and examples for inspiration

Web and print

- Photographs of varied landforms
- Driving Question Board (DQB) to keep track of class and student questions
- Step 2: Texts of interviews with Fire Ecologists- Toni and interview for Toni, Chris and interview for Chris; and Katie and interview for Katie and Amanda and interview for Amanda
- Step 3 Graph that illustrates how many uncontrolled fires there were in the United States from 1985 to 2014. Further figures can be found on the IPCC website, for example, here.
- Step 4 The fire triangle
- Step 6 Six photos of a forest responding after a controlled fire; Time-lapsed video

Other

- Household materials to build stream tables: containers, earth materials (sand and rocks)

Opportunities to adapt, extend, and enrich

- This mini-unit is based on portions of the first two learning sets in a sequence of five learning sets. Remaining learning sets have students examine how different fire ecologists respond to a concern in their environments, and how fire serves as one important tool in their toolbox.
- Remaining learning sets, along with additional STEM project-learning units and related resources can be found at https://sprocket.lucasedresearch.org/course/science4/fire-ecology and https://mlpbl.open3d.science/ ML-PBL Units were co-developed by the Multiple Literacies in Project-based Learning Project at Michigan State University and the University of Michigan 2018–2020. ML-PBL units are licensed under a Creative Commons Attribution-NonCommercial 4.0 International License and were funded by the George Lucas Educational Foundation.

Creativity and critical thinking rubric for science

Mapping of the different steps of the lesson plan against the OECD rubric to identify the creative and/or critical thinking skills the different parts of the lesson aim to develop

	CREATIVITY Coming up with new ideas and solutions	Steps	CRITICAL THINKING Questioning and evaluating ideas and solutions	Steps
INQUIRING	Make connections to other scientific concepts or conceptual ideas in other disciplines	2,3	Identify and question assumptions and generally accepted ideas of a scientific explanation or approach to a problem	1,2,6
IMAGINING	Generate and play with unusual and radical ideas when approaching or solving a scientific problem	4,5,6	Consider several perspectives on a scientific problem	3
DOING	Pose and propose how to solve a scientific problem in a personally novel way	7,8	Explain both strengths and limitations of a scientific solution based on logical and possibly other criteria (practical, ethical, etc.)	4,7,8
REFLECTING	Reflect on steps taken to pose and solve a scientific problem	8	Reflect on the chosen scientific approach or solution relative to possible alternatives	7,8