iPlan: Mapping the Future

A Curriculum Guide for Mass Audubon Educators

Mass Audubon

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

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Acknowledgements

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Introduction

Developed through a partnership between Mass Audubon and the University of Wisconsin Epistemic Lab, iPlan is a free, online land-use planning game that allows learners to construct, investigate, and solve simulated urban and regional planning problems.

The system uses geospatial data, ecological and economic models, and optimization routines to transform any location in the contiguous United States into an interactive land use planning simulation.

Suitable for use on smart phones, tablets, Chromebooks, and laptops, the game allows learners to explore the impacts of land-use decisions in their own local contexts. Just choose a location using the Google Maps interface, choose the issues you want to explore, and then start making land-use changes.

Players construct rezoning plans that address socioeconomic and environmental issues, and their plans are evaluated by virtual stakeholders who advocate for different community priorities. Will your changes please community leaders, or will you have to go back to the drawing board?

About This Guide

This curriculum guide is for any formal or informal educators who are interested in using iPlan and would like supporting curriculum for the game. Each of the lesson plans below provides curriculum on a theme and recommendations for how to teach about that topic in conjunction with the iPlan game. Each lesson plan also provides relevant topical information

on the theme. The lesson plans each include a goal and objective for the lesson, a challenge scenario to guide students toward the goal and objectives, and pre- and post-activity discussion questions. Some basic instructions for using iPlan are included, but the built-in tutorial within the game is recommended for learning how to navigate the various tools.

Next Generation Science Standards Connections

In addition to being an innovative learning tool, iPlan promotes development aligning with many Next Generation Science Standards (NGSS) for learning, including:

- Asking questions and defining problems
- Developing and using models
- Analyzing and interpreting data
- Using mathematical and computational thinking
- Planning and carrying out investigations
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

NGSS Engineering Design with iPlan

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

NGSS Earth, Space and Life Science with iPlan

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

HS-ESS3-3. Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Lesson Plan 1: Climate Change

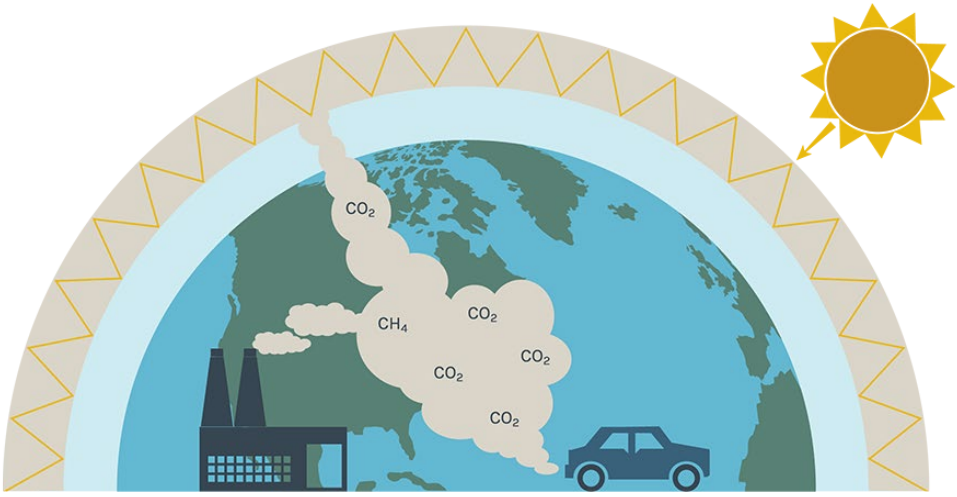
Theme
Urban/City/Community Planning as it relates to Climate Change

Goal
Introducing students to how different types of land use plays a part in global warming

Objective
- Discuss global warming, land use, the role of plants in climate change
- Identify two land-use codes that can have negative climate impacts on a community and explain why
- Provide examples of three land use changes that can lead to climate change solutions and why

Challenge Scenario
You are a climate scientist working toward mitigating global warming. Create a land use plan that decreases greenhouse gasses by changing the land use of the parcels, while pleasing as many stakeholders as you can.

Indicators Suggested
- Heat Advisory Days
- Butterflies
- Greenhouse gasses
- Housing
- Population



Discussion: Introduction to Climate Change
- Ask students: What do you know about climate change?
- What is climate change?
    - Climate change includes both the global warming driven by human emissions of greenhouse gases and the resulting large-scale shifts in weather patterns.
- What are greenhouse gasses?

    - A greenhouse gas is a gas that absorbs and emits radiant energy within the thermal infrared range. Greenhouse gases cause the greenhouse effect on planets. The primary greenhouse gases in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.
- What is the Greenhouse Effect?
    - Humans burn fossil fuels like coal, oil, and natural gas.
    - These fossil fuels release excess greenhouse gasses, like carbon dioxide (CO_2), into the atmosphere.
    - The atmosphere wraps around Earth like a blanket, trapping energy from the sun inside of it. Excess greenhouse gasses make this blanket thicker, trapping more heat and causing our world to warm rapidly.
    - The blanket has become too thick, which hurts plants, animals, and humans.

▶ Watch a short Ted Talk to help inform the discussion: Kristen Bell/Giant Ant: Why is the world warming up?

Discussion: Effects & Responses to Climate Change

- Ask students: What are the effects of climate change?
    - Fires, flooding, warming temperatures, sea level rise, drought, heavy rain, habitat loss, severe weather, heat waves
- Can you think of how plants are important to mitigate global warming?
    - CO_2 sinks, areas of cooling, flood mitigation/absorbs water
- What is net-zero/carbon-neutral?
    - Carbon neutrality refers to achieving net-zero carbon dioxide emissions by balancing carbon dioxide emissions with removal or simply eliminating carbon dioxide emissions altogether.

▶ Watch a short Ted Talk to help inform the discussion: Kristen Bell/Giant Ant: What is net-zero?

- How can you draw down your climate impact?
    - Eating less meat and dairy: even cutting meat out one day of the week helps
    - Decreasing food waste: meal planning, only taking what food you need, eat leftovers, compost
    - Decreasing transportation: walking/biking, public transit, buy a hybrid or electric vehicle, carpool, if you have to drive don't speed up and slow down quickly
    - Having smaller families
    - Voting for local and national officials that support green laws
    - Shopping locally to reduce shipping of goods
    - Small habit changes like taking shorter showers, using energy efficient light bulbs, avoiding single-use plastic, attend town meetings and vote on local changes like preserving land
    - Pursuing a career a green field: Become a city planner and design net-zero communities or an architect that designs green buildings
    - Work toward making changes at your school
    - Type in the chat or say one thing you will do to draw down your climate impact

iPlan Tutorial

- Create a map using the indicators above and send link to students
- Have students open map and go through the "Kira" tutorial
    - Click the hamburger icon in the bottom left, click "tutorial"
- After the tutorial, have the students read additional information about the indicators and stakeholders.
    - Click the hamburger icon on the bottom left, click resources to access information

Climate Change Challenge

Once students have had a chance to play with the tool and get comfortable with the process, present them with the Climate Change Challenge Scenario.

- Practice changing parcels in the map, focusing on how land use changes cause indicators to change
- Reflect and share what worked and didn't work to cause indicators to change
- Run iPlan, submitting maps to stakeholders
    - Show again how to submit map to stakeholders and remind the students the number of submissions is limited
    - Remind them they only have a certain number of chances for feedback, so don't do them all every time
- Tell students they may take a screen shot of their map submissions so they can go back and remember what it looked like
- Pause class to show how to set targets on the indicator graphs
- Finish iPlan game and have students make their final map submission

Wrap Up

Split students into groups to talk about similarities and differences in each map, then share as a class. Talk about similarities and differences in each map and what it was like trying to please all the stakeholders. How many were you able to please while decreasing GHG?

Lesson Wrap-up Videos

- Ted Talk by Angel Hsu: Cities are driving climate change. Here's how to fix it.
- Ted Talk by Yvonne Aki-Sawyerr: The city planting a million trees in two years

Discussion Questions

- How does land use affect climate change?
    - Identify two land-use codes that can have negative climate impacts on a community and explain why
    - Provide examples of three land use changes that can lead to climate change solutions and why
- Explain what role plants have in climate change

Lesson Plan 2: Ecological Restoration

Theme

Restoration of degraded ecosystems is an important action to increase biodiversity and mitigate the impacts of climate change, and how land use plays a part

Goal

To introduce students to the science of ecosystem restoration and why it's important to our understanding

Objective

- Define the term restoration and identify locations in the school yard that could undergo restoration in order to improve ecosystem health and habitat connectivity
- Create a map that increases ecosystem function, specifically butterfly population, and connectivity while balancing community development needs

Challenge Scenario

You are an ecologist. Create a land use plan that restores ecosystem functions for the community—specifically, increasing butterfly populations—by changing the land use of the parcels, while pleasing as many stakeholders as they can.

Indicators Suggested

- Greenhouse gas emissions
- Bird Population
- Butterfly Population
- Open Space Access
- Population

Introduction to Restoration Ecology

- What do you think of when you hear "ecology"?
    - **Ecology**: The relationship of organisms to one another and to their physical surroundings
- Do you know what ecological restoration is or involves?
    - **Ecological restoration:** renewing and restoring degraded, damaged, or destroyed ecosystems and habitats in the environment using active human intervention and action
        - Example: Removing an old mill dam and restoring the river

> *"Ecological restoration aims to recreate, initiate, or accelerate the recovery of an ecosystem that has been disturbed. Disturbances are environmental changes that alter ecosystem structure and function. Common disturbances include logging, damming rivers, intense grazing, hurricanes, floods, and fires. Restoration activities may be designed to replicate a pre-disturbance ecosystem or to create a new ecosystem where it had not previously occurred. Restoration ecology is the scientific study of repairing disturbed ecosystems through human intervention."*
> *—Vaughn et. al., 2010*

Activity

Students should go outside and assess the land use at their school or home.

- What is the land is being used for? i.e. buildings, open space, agriculture, residential
    - How much human impact is there?
    - What is the ecology of the school yard/backyard?
- How can we increase pollinators at the school yard/ in your backyard? Can we restore an area by creating a new monarch habitat area?
    - Why is this beneficial?
        - Increase plant populations which helps grow the food chain
        - More green space = less temperature rise/less greenhouse gas emissions
        - Pollinations to make more flowers/fruit and attract more pollinators
    - What hurdles might we face trying to do that?
        - Time, money, would the board and principle/your parents agree or do they have something else in mind for the land, land availability
- Brainstorm ideas of how to restore pollinators, specifically monarchs.
- Draw/design elements of a restoration in groups
- Share with the class

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Ecological Restoration Challenge

Once students have had a chance to play with the tool and get comfortable with the process, present them with the Ecological Restoration Challenge Scenario.

- Practice changing parcels in the map focusing on how land use changes cause indicators to change
- Reflection/ Share out on what worked and didn't work to cause indicators to change
- Run iPlan submitting maps to stakeholders
    - Show again how to submit map to stakeholders and remind the students the number of submissions is limited
    - Remind them they only have a certain number of chances for feedback, so don't do them all every time
- Tell students they may take a screen shot of their map submissions so they can go back and remember what it looked like
- Pause class to show how to set targets on the indicator graphs
- Finish iPlan game and have students make their final map submission

Wrap Up

Split students into groups to talk about similarities and differences in each map, then share as a class. Talk about similarities and differences in each map and what it was like trying to please all the stakeholders. How many were you able to please while also increasing ecological function/butterfly populations?

Discussion Questions

- How does land use affect a restoration project?
- How does stakeholder input affect a restoration project?
- How does the restoration of degraded landscapes help address climate change vulnerabilities that affect local communities?

Lesson Plan 3: Sustainability

Theme

Sustainability; use of alternative energy for clean air

Goal

Introducing students to alternative energy and how land use plays a role in clean air

Objective

- Discuss sustainability, alternative energy, clean air related to alternative energy, GHG
- Identify two land-use codes that can have negative impacts on clean air
- Provide examples of three land use changes that can lead to clean air
- Explain what role alternative energy has in climate change

Challenge Scenario

You are an engineer working toward mitigating global warming by using alternative energy. Create a land use plan that decreases pollution and greenhouse gasses by changing the land use of the parcels, while pleasing as many stakeholders as you can.

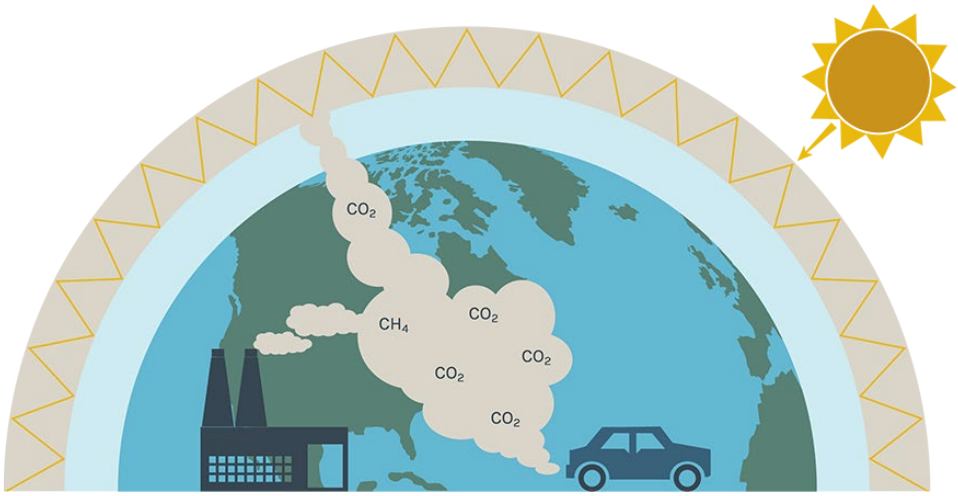
Indicators Suggested

- Heat Advisory Days
- Birds
- Greenhouse gasses
- Housing
- Population or sales

Discussion: Sustainability

- Describe sustainability
    - **Sustainability**: Avoidance of the depletion of natural resources in order to maintain an ecological balance
- Alternative energy
    - Avoid depletion of natural resources by creating energy through renewable sources rather than conventional. They have lower carbon emissions. Renewable sources are naturally replenished on a human time scale.
    - Have the students name some examples of alternative energy
        - Sun, wind, rain, tides, waves, geothermal heat
    - The most successful types of alternative energy that we use today are wind turbines and solar panels
    - Why is it good to use alternative energy compared to conventional (coal, natural gas, oil)?
        - Produces no carbon or other pollutants into the air; clean air
- **Greenhouse Gas**: A gas that contributes to the greenhouse effect by absorbing and then re-radiating infrared rays
    - Carbon dioxide is a greenhouse gas (GHG)
    - GHG contribute to global warming

- Alternative energy can help mitigate global warming because it doesn't produce these GHGs



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Sustainability Challenge

Once students have had a chance to play with the tool and get comfortable with the process, present them with the Sustainability Challenge Scenario.

- Practice changing parcels in the map focusing on how land use changes cause indicators to change
- Reflection/ Share out on what worked and didn't work to cause indicators to change
- Run iPlan submitting maps to stakeholders
  - Show again how to submit map to stakeholders and remind the students the number of submissions is limited
  - Remind them they only have a certain number of chances for feedback, so don't do them all every time
- Tell students they may take a screen shot of their map submissions so they can go back and remember what it looked like
- Pause class to show how to set targets on the indicator graphs
- Finish iPlan game and have students make their final map submission

Wrap Up

Split students into groups to talk about similarities and differences in each map, then share as a class. Talk about similarities and differences in each map and what it was like trying to please all the stakeholders. How many were you able to please while decreasing pollution and greenhouse gasses?

Lesson Wrap-up Videos

- Ted Talk by Kristen Bell/Giant Ant: What is net-zero?
- Ted Talk by Angel Hsu: Cities are driving climate change. Here's how to fix it.

Discussion Questions

- Identify two land-use codes that can have negative impacts on clean air
- Provide examples of three land use changes that can lead to clean air
- Explain what role alternative energy has in climate change

Lesson Plan 4: Urban Ecology

Theme

Urban ecology relating to birds

Goal

Introducing students to how different types of land use, urban and not urban, plays a part in ecology relating to birds

Objective

- Discuss land use, ecology, urban ecology, bird ecology
- Create a map that increases bird population while balancing community development needs
- Define urban ecology and why it's important to understand it
- List two ways that land use is related to urban ecological issues
- Explain the role stakeholders have in how an urban landscape is developed

Challenge Scenario

Create a land use plan that increases bird populations by changing the land use of the parcels, while pleasing as many stakeholders as you can.

Indicators Suggested

- Birds
- Butterflies
- Greenhouse gasses
- Housing
- Population

Discussion: Urban Ecology

- What do you think of when you hear "ecology"?
    - What have you learned or do you know about urban ecology?
- Urban Ecology
    - **Urban ecology**: The relationship between living organisms and their surroundings in an urban setting
    - Give an example of land defined as urban
        - "Land defined as urban" refers to towns and cities dominated by high-density residential and commercial buildings and paved surfaces
    - The goal of urban ecology is to achieve a balance between human culture and the natural environment
    - The study of urban ecology carries increasing importance because more than 50% of the world's population today lives in urban areas
    - We need to understand how animals survive in this type of habitat
    - What ecological issues are caused by urban land use?
        - Decreased diversity of animal species due to habitat removal
        - Increased greenhouse gasses
        - Urban heat island effect
        - Acid rain and pollution

- Migratory birds in urban habitats
    - How might urban habitats affect migratory birds?
        - Urban land use destroys bird habitat, so they will no longer make cities their home
        - Heat in the city will change their migratory patterns, including the time of year they migrate

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Urban Ecology Challenge

Once students have had a chance to play with the tool and get comfortable with the process, present them with the Urban Ecology Challenge Scenario.

- Practice changing parcels in the map focusing on how land use changes cause indicators to change
- Reflection/ Share out on what worked and didn't work to cause indicators to change
- Run iPlan submitting maps to stakeholders
    - Show again how to submit map to stakeholders and remind the students the number of submissions is limited
    - Remind them they only have a certain number of chances for feedback, so don't do them all every time
- Tell students they may take a screen shot of their map submissions so they can go back and remember what it looked like
- Pause class to show how to set targets on the indicator graphs
- Finish iPlan game and have students make their final map submission

Wrap Up

Split students into groups to talk about similarities and differences in each map, then share as a class. Talk about similarities and differences in each map and what it was like trying to please all the stakeholders. How many were you able to please while increasing bird populations?

Lesson Wrap-up Videos

- Ted Talk by Noah Wilson-Rich: Every city needs health honey bees

Discussion Questions

- Explain the role stakeholders have in how an urban landscape is developed
- How does land use affect climate change?
- How does climate change affect migratory birds?

Lesson Plan 5: The Urban Heat Island Effect & Genetic Diversity

Theme
Urban Heat Islands and Genetic Diversity

Goal
Introducing students to how different types of land use relate to urban heat island effects

Objective
- Discuss heat island effects, land use, natural corridors, genetic diversity
- Identify two land-use codes that can lead to urban heat island
- Provide examples of three land use changes that can lead to a natural corridor

Challenge Scenario
You are an ecologist studying how urban heat islands affect genetic diversity in animals. Create a land use plan that decreases heat advisory days and impervious surfaces by changing the land use of the parcels, while pleasing as many stakeholders as you can.

Indicators Suggested
- Heat Advisory Days
- Impervious surfaces
- Birds
- Butterflies
- Population

Discussion: Urban Heat Islands & Natural Corridors
- What is one memory you have of being particularly hot and not having the ability to cool down? Where were you?
- Heat Islands
    - **Heat islands**: urbanized areas that experience higher temperatures than outlying areas. Structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies.
    - How can we prevent a heat island from occurring?
        - Green corridors
        - Conservation/natural areas
        - Urban parks
    - **Green corridor**: an area of habitat connecting wildlife populations separated by human activities or structures (such as roads, development, or logging).
- What types of land use would cause a heat island?
- What types of land use would create a green corridor?

▶ Read these articles to help inform the discussion:

- Detailed Maps of Urban Heat Island Effects in Washington, DC, and Baltimore
- National Geographic: Urban Heat Island encyclopedia entry

- Genetic Diversity
    - How might having heat islands affect the plants and animals that live there?
        - They will leave
        - They will not be able to grow or live in the place they used to
        - Migration patterns will change
        - The area's species will become less diverse

▶ Watch a short Ted Talk to help inform the discussion: Angel Hsu: Cities are driving climate change. Here's how to fix it.

iPlan Tutorial

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Urban Heat Island Challenge Scenario

Once students have had a chance to play with the tool and get comfortable with the process, present them with the Urban Heat Island Effect Challenge Scenario.

- Practice changing parcels in the map focusing on how land use changes cause indicators to change
- Reflection/ Share out on what worked and didn't work to cause indicators to change
- Run iPlan submitting maps to stakeholders
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    - Remind them they only have a certain number of chances for feedback, so don't do them all every time
- Tell students they may take a screen shot of their map submissions so they can go back and remember what it looked like
- Pause class to show how to set targets on the indicator graphs
- Finish iPlan game and have students make their final map submission

Wrap Up

Split students into groups to talk about similarities and differences in each map, then share as a class. Talk about similarities and differences in each map and what it was like trying to please all the stakeholders. How many were you able to please while decreasing heat advisory days and impervious surfaces?

Lesson Wrap Up Videos

- Ted Talk by Stefan Al: What happens if you cut down all of a city's trees?

Discussion Questions

- How does land use cause urban islands?
- Identify two land use codes that can lead to urban heat islands
- Provide examples of three land use changes that can lead to a natural corridor
- How do urban heat islands contribute to climate change?
- What can you do?
    - Top GHG decreasing habits are:
        - Eating less meat and dairy—even cutting out meat one day per week helps
        - Decreasing food waste—meal planning, only taking as much food as you need, eating leftovers, composting
        - Decreasing transportation—walking/biking, public transit, if you have to drive don't speed up and slow down quickly, buy a hybrid vehicle
        - Smaller families
        - Voting for local and national officials that support green laws

Lesson Plan 6: Water Quality

Theme

Restoring degraded ecosystems to improve water quality and to mitigate the impacts of climate change

Goal

To introduce students to the science of ecosystem restoration relating to water quality and how land use plays a part

Objective

- Discuss restoration, water quality, surface water runoff, phosphorous pollution and land use
- Create a map that increases water quality while balancing community development needs

Challenge Scenario

Create a land use plan that restores ecosystem functions for the community by increasing water quality. Specifically, decrease impervious surfaces and phosphorous pollution by changing the land use of the parcels, while pleasing as many stakeholders as you can.

Indicators Suggested

- Greenhouse gas emissions
- Heat advisory days
- Phosphorous
- Impervious Surfaces
- Population

Discussion: Water Quality

- What have you previously learned about water quality?
- What is one word you think of when you hear “water quality?”
- Water Quality:
    - **Water quality**: the condition of water relating to chemical and physical characteristics with respect to its suitability for purposes such as swimming and drinking
    - What causes poor water quality?
        - Pollution
        - Surface runoff
        - Global warming (Increased temperatures and heat advisory days lead to increased water temperatures; warm water holds less dissolved oxygen (DO), so chemical reactions increase)
- Water quality indicators on the iPlan map
    - Phosphorous
        - Phosphorous is a common constituent of agricultural fertilizers, manure, and organic wastes in sewage and industrial effluent

        - When the levels of the chemicals phosphorous and nitrogen are too high in water they speed up eutrophication (a reduction in dissolved oxygen in water bodies caused by an increase of mineral and organic nutrients) of rivers and lakes
        - It is an essential element for plant life, but when there is too much of it in water it reduces the dissolved oxygen
        - Soil erosion is a major contributor of phosphorus to streams
    - Impervious surfaces
        - What do you think of when you hear "Impervious"
        - **Impervious**: not allowing fluid to pass through
        - The more impervious the surface, the more runoff, pollution, and extra nutrients in a stream
        - Ask students for examples of impervious surfaces
            - Parking lots
            - Buildings
            - Paved roads

Water Quality Activity

- Use the Model My Watershed – Runoff Simulation tool to demo
    - What surfaces increase runoff the most?
    - Which decrease runoff?
    - How does soil type/size influence surface runoff?
        - Size of the particles causes the ability for some soils to absorb more than others
    - What's the difference between clay, silt, sand?
        - Size of the sediment particles
    - Which soil types do you think cause more runoff?
        - More permeable like sand, more infiltration; less permeable like clay, more runoff
    - What habitats would cause the least runoff?
        - Forests, wetlands, etc.
        - Why? What kind of surfaces do they have?
        - Wetlands and other habitat types like forests are valuable because they are great sponges for runoff and could be priority habitat types for restoration projects

Discussion: Ecological Restoration

- Scientists and community members take on restoration projects of wetlands such as rivers to improve water quality
- What do you think ecological restoration means?
    - Ecological restoration
        - **Ecology**: relationships of organisms to one another and their habitat
        - **Ecological Restoration**: Renewing and restoring degraded, damaged, or destroyed ecosystems and habitats in the environment by active human intervention and action

iPlan Tutorial

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Water Quality Challenge Scenario

Once students have had a chance to play with the tool and get comfortable with the process, present them with the Water Quality Challenge Scenario.

- Practice changing parcels in the map focusing on how land use changes cause indicators to change
- Reflection/ Share out on what worked and didn't work to cause indicators to change
- Run iPlan submitting maps to stakeholders
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    - Remind them they only have a certain number of chances for feedback, so don't do them all every time
- Tell students they may take a screen shot of their map submissions so they can go back and remember what it looked like
- Pause class to show how to set targets on the indicator graphs
- Finish iPlan game and have students make their final map submission

Wrap Up

Split students into groups to talk about similarities and differences in each map, then share as a class. Talk about similarities and differences in each map and what it was like trying to please all the stakeholders. How many were you able to please while decreasing phosphorous pollution and impervious surfaces?

Discussion Questions

- How does land use and stakeholder input affect a restoration project (i.e. restoring the water quality)?
- How does the restoration of degraded landscapes, in this case water quality, help address climate change vulnerabilities that affect local communities?

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