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Introduction

Thank you for using this Raising Educational Achievement through Cultural Heritage Up (REACH Up) unit in your classroom! The lessons are designed to address the Alaska Science Standards and Grade Level Expectations, Alaska Cultural Standards and the Bering Strait School District Scope and Sequence goals. All of the activities focus on shrub expansion and related ecological changes from Alaska Native cultural, physical and earth science perspectives. This supplemental unit addresses the place-based question: How is the vegetation changing in our area and why are these changes important to our community?

The REACH Up Shrub Expansion unit consists of three activities. Each activity will require a 45-minute class period; discussion could easily be extended into multiple class periods. You may also want to repeat sections of an activity during subsequent class meetings, such as reviewing the Vegetation Changes video or having your students practice the vocabulary card games multiple times. If you are utilizing the entire Shrub Expansion unit, you should introduce the activities in the order they are presented. However, if time is short, any of the activities could be presented independently.

The accompanying student guide is intended for use with multiple groups of students and you should not allow students to write in them. You can either have students record their work on a separate sheet of paper, or create copies of the corresponding worksheets that are included in this teacher's guide.

Whole Picture

Through millennia of living off the land, Alaska Native people have developed an intimate understanding of their surroundings. From generation to generation, people learned to read details about the environment from their relatives, elders, and other community members. People innately knew when particular animals would arrive on the landscape and when certain plants would be right for harvesting. This deep knowledge of the landscape was vastly important for survival, and in many communities was woven into the language. Activities that happened at certain times of the year were reflected in the meaning of month names. We see this still in Native communities like Golovin where the Native words for April, May, June, and July have meanings that reflect subsistence activities: "the month when people go out with the umiaq" (April), "the month when caribou lay their fawns" (May), "the month of small fish" (June), and "the month when birds molt" (July) (Wood and Bautnuq, part 1).

Understanding seasonal timing is an important scientific skill that enables people to understand the life cycles of the "rich array of vegetation, including numerous edible greens and berries" upon which they depend (Fienup-Riordan and Rearden, 2012, p. 13). Plant identification — both

their names and how they are used — is a crucial aspect of learning this skill. Plants provide people with much needed nutrients to balance out their diets, medicinal properties to heal the ailing, and resources to use in tool and craft making.

Traditionally, plant identification skills and uses were passed from generation to generation through long hours of observation and hands-on learning. Young people would go out on the land with their elders and family members to pick berries, harvest plants, observe the world around them, and then spend many hours learning to prepare the food for immediate eating or for storage to be eaten at a later time (Fienup-Riordan and Rearden, 2012; Kawagley, 2006; Krupnik and Jolly, 2002; Matthews, 1968). Today, harvesting plants and putting food up for winter is no less important, but young people spend less time out on the land with the people who can teach them proper identification and harvesting techniques. Nevertheless, elders and culture bearers identify these skills as essential for young people to learn.

Still, "the world is faster now" (Krupnik and Jolly, 2002) — scientists and culture bearers alike have noted alarming changes happening to plants as the result of climate change — changes that are making it difficult to know the land. Jeanette L. Aya, from Savoonga, has noticed that plants are growing faster than normal now. In the past, she says it was "as though time stood still" — people had time to gather and prepare food for winter storage. Now, the plants are nearly useless by the time they are first noticed (Aya, 2011), and people are finding it more and more difficult to get everything done. In the past, berry season followed the fishing season. Now, though, people often find themselves trying to gather berries at the same time as they need to be cutting and drying fish — this makes for challenging work and some are finding it difficult to put up enough food for winter.

As climate continues to change, people will witness more and more change, making traditional practices more and more difficult. It is therefore ever more important for young people to spend more time getting to know the plants and animals, not only so that the changes can be understood, but so that people can learn how to adapt to the changes and continue to survive.

References

Aya, Jeanette L. (2011). *Stories About Adaptation and Subsistence: Native Voices from the Frontlines of Climate Change*. Aksik. Accessed from: http://aksik.org/village/savoonga.

Fienup-Riordan, Ann, and Alice Rearden. (2012). *Ellavut: Our Yup'ik World and Weather*.

Continuity and change on the Bering Sea Coast. Seattle and London: University of Washington Press.

Kawagley, Angayuqaq Oscar. (2006). *A Yupiaq Worldview: A Pathway to Ecology and Spirit*. Long Grove: Waveland Press.

Krupnik, Igor, and Daynna Jolly. (2002). *The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change*. Arctic Research Consortium of the United States and Smithsonian Institution Presses.

Matthews, Donna. (1968). *Aleut Plants*. Association of Unangan/Unangas Educators and the Unangam Elders' Academy. Alaska Native Knowledge Network.

http://ankn.uaf.edu/ANCR/Aleut/Unangam/UnangamHitnisangin/toc.html.

Wood, Cheryl Ann, and Bautnuq Punguk, Kylee. (n.d.). *Plants of My People: The Iñupiaq of Golovin Bay, Norton Sound, Alaska*. Alaska Native Knowledge Network. Accessed from: http://ankn.uaf.edu/ANCR/Inupiaq/plantsofmypeople/index.html.

Unit Vocabulary

Science Terms to Define	
shrub	a woody plant smaller than a tree, usually having multiple permanent stems brancing from or near the ground
shrub expansion	the northward and upslope encroachment of trees and shrubs into tundra-dominated areas
tundra[1]	a cold and dry biome that is characterized by short vegetation such as grasses, mosses, and lichens

Terms for Incorporating Local Indigenous				
English	**Iñupiaq**	**Yup'ik**	**Siberian Yupik**	**Local Translation**
shrub	uqpik	cuyaqsak	uqfilleqgaq	
willow	uqpik	uqvik	uqvigaq	
tundra	nuna	nunapik	nunivak	
treeline	napaaqtut	apat ngeliit	uqfiget	

[1]2012 Glencoe McGraw Hill Life Science Textbook definition:

tundra = *a biome that is cold, dry, and treeless*

This is also an accurate definition and teachers may want to use their textbook's terminology for consistency. We have provided an alternative definition to emphasize what the tundra has rather than what it lacks.

Activity MS.5.1: Ask an Expert

Overview

In this activity, students will interview an elder or cultural knowledge bearer.

Objectives

On successful completion of the lesson, students will be able to:

- demonstrate effective interviewing techniques
- interpret qualitative data from interviews
- describe how vegetation in the local ecosystem is changing

Alaska Standards

Alaska Science Standards / Grade Level Expectations

[6-8] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[6] SA3.1 The student demonstrates an understanding that interactions with the environment provide an opportunity for understanding scientific concepts by gathering data to build a knowledge base that contributes to the development of questions about the local environment (e.g., moose browsing, trail usage, river erosion).

Alaska Cultural Standards

[D] Culturally-knowledgeable students are able to engage effectively in learning activities that are based on traditional ways of knowing and learning. Students who meet this cultural standard are able to:

[D.4] gather oral and written history information from the local community and provide an appropriate interpretation of its cultural meaning and significance.

[E] Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them. Students who meet this cultural standard are able to:

[E.2] understand the ecology and geography of the bioregion they inhabit.

Bering Strait School District Scope & Sequence

6.9G Understand how ecosystems change over time.

Materials

- REACH Up Middle School Student Guide: *Shrub Expansion*
- Student Worksheet: *Ask an Expert about Shrub Expansion*
- Internet access and projector

Activity Preparations

1. Identify adults within your school who have lived year-round in the community for many years. This might include teachers, administrators, secretaries, teacher aides, lunchroom/kitchen staff, recess duties, maintenance and custodial staff, etc. Ask these local knowledge bearers if they would be willing to speak with a group of your students about how vegetation in the area has changed, and how those changes have affected the community. Make sure that the volunteers you have identified will be available during the time that your class will be completing this activity.
2. Ask the volunteers if they speak an Alaska Native Language, and if so, which language(s) and dialect(s) they are familiar with. If applicable, have them translate the written words on the student worksheet, so you have an answer key. Also, ask them to teach you the pronunciation of the terms.

Activity Procedure

1. Distribute the Shrub Expansion student guide and ask students to work with a partner to read pages 1-4.
2. Show the video, Vegetation Changes, available at www.k12reach.org/videos.php. Videos are located under the Multimedia tab. Allow time for students to share comments and ask questions.
3. Explain that students will interview a few community members about local vegetation changes. Separate students into small groups according to how many knowledge bearers are available to share lake information with your class. Explain if the appointed interviewees speak an Alaska Native Language, so students know whether or not they should pursue that portion of the interview.
4. Review expectations for student behavior while conducting the interview, including introductions and thanking the interviewee at the end of the interview. Discuss suggestions for effective interviewing techniques, such as allowing ample time for the interviewee to answer, and asking follow-up questions.
5. Distribute one Student Worksheet: Ask an Expert about Shrub Expansion to each group and assign each group one local knowledge bearer to interview. Provide 15-20 minutes for students to locate and interview the knowledge bearer.
6. Reconvene in the classroom and ask groups to share their findings. How has the local vegetation changed? What impacts might the changes have on local lifestyles?

Student Worksheet: Ask an Expert about Shrub Expansion

Names of Group Members:_____

_____

Interview a long-term community member to learn more about vegetation in your area. Take notes about what you learn.

Who did you interview? _____

Ask:

How has the vegetation changed in this area in your lifetime?

Have changes in vegetation affected hunting, berry picking, and/or transportation?

Other notes:

For Alaska Native Language Speakers:

What language(s) do you speak? _____

What dialect(s)?_____

Could you translate the following words?

shrub: _____

willow: _____

tundra: _____

treeline: _____

Activity MS.5.2: Shrub Expansion Vocabulary

What terminology do we need to know to discuss shrub expansion?

Overview

In this activity, students will learn key shrub expansion terminology in English and their local Alaska Native language by playing vocabulary games with peers.

Background Information

Based on the Visual Iñupiaq Vocabulary Acquisition (VIVA) Program of the North Slope Borough School District, the vocabulary cards provided for this activity have Alaska Native Language and English terms and an associated image. The games suggested are meant to promote fluency through repeated practice. Other vocabulary cards can be easily integrated into the games. This will extend potential length of the games and add a greater challenge. By working with the words through different games, students can develop greater fluency with the vocabulary.

Objectives

On successful completion of this lesson, students will be able to:

- read and speak indigenous terms related to climate, landscape and ecosystems
- illustrate and define terms related to shrub expansion and landscape changes in their region

Alaska Cultural Standards

[B] Culturally-knowledgeable students are able to build on the knowledge and skills of the local cultural community as a foundation from which to achieve personal and academic success throughout life. Students who meet this cultural standard are able to:

[B.2] make effective use of the knowledge, skills, and ways of knowing from their own cultural traditions to learn about the larger world in which they live.

[E] Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them. Students who meet this cultural standard are able to:

[E.2] understand the ecology and geography of the bioregion they inhabit.

Bering Strait School District Scope & Sequence:

6.9G Understand how ecosystems change over time.

Materials

- REACH Up Middle School STUDENT GUIDE: *Shrub Expansion*
- Vocabulary card sets (1 per group of 4-6 students)
- Dry Erase Markers (1 per group)
- Word Games Instruction Sheet (1 per group of students)
- Worksheet: *Shrub Expansion Vocabulary*
- Timers (optional)

Activity Preparations

1. If your students completed Activity MS.5.1 Ask an Expert, refer to their completed worksheets to for the terms you will have them use for the vocabulary word card games.
2. If your students did not conduct interviews with Native language speakers, consult with a local knowledge bearer or language expert to determine which language/dialect translation provided on Page 5 of the Student Guide would be most appropriate for your students to practice. The following chart is provided for reference.

Alaska Native Languages in the Bering Strait Region				
Language	**Dialect Group**	**Dialect**	**Subdialect**	**Community**
Iñupiaq	Seward Peninsula Inupiaq	Bering Strait		Brevig Mission
			Diomede	Little Diomede
				Shishmaref
			Wales (Kinikmiu)	Wales
		Qawariaq	Teller	Teller
				Unalakleet
				Shaktoolik
			Fish River	Golovin*
				White Mountain
	Northern Alaskan Iñupiaq	Malimiut		Koyuk
Siberian Yupik		St. Lawrence Island Yupik		Gambell
				Savoonga
Yup'ik		Norton Sound (Unaliq-Pastuliq)	Unaliq	Elim
				Golovin*
				St. Michael
		General Central Yup'ik	Nelson Island and Stebbins	Stebbins

* It is very common for more than one language / dialect, or a combination of dialects, to be spoken in a community. It should also be noted that Inupiaq-Yup'ik bilingualism was common throughout the 1900s in the Norton Sound villages of White Mountain, Golovin, Elim, and Unalakleet. Golovin is listed twice on our chart because specific subdialects were cited in the research found on the Alaska Native Language Center website: http://www.uaf.edu/anlc/languages/.

3. Keep in mind that different individuals may translate certain terms differently. For example, some languages may not have a separate term for "shrub" and "willow". Or, distinct terms may exist, but the individual speaker does not know the term for "willow", and uses the term for "shrub" in both instances. It's fine to have different student groups working with various translations, or you can choose a set list of words for your whole class to practice. Highlight the diversity and do not attempt to offer an authoritative translation; the goal is to practice an Alaska Native language while discussing climate change topics.
4. If using the Vocabulary Cards provided by REACH Up, label a sample set of cards with local indigenous words using a dry erase marker. If needed, create your own sets of the

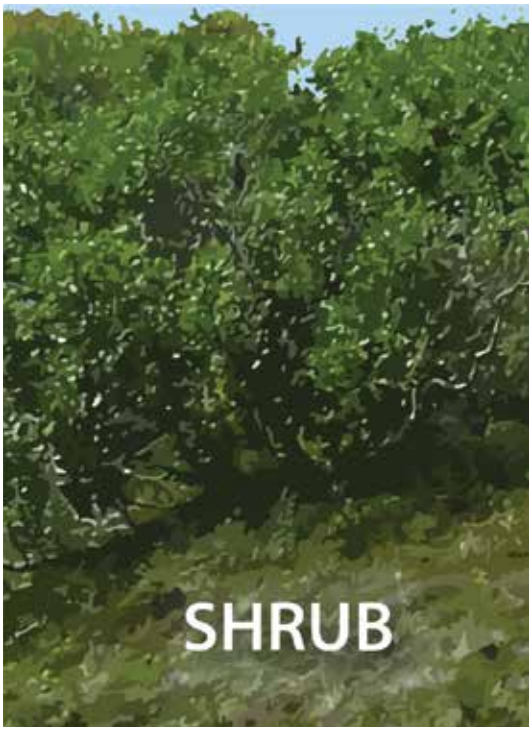
vocabulary cards from the template provided.

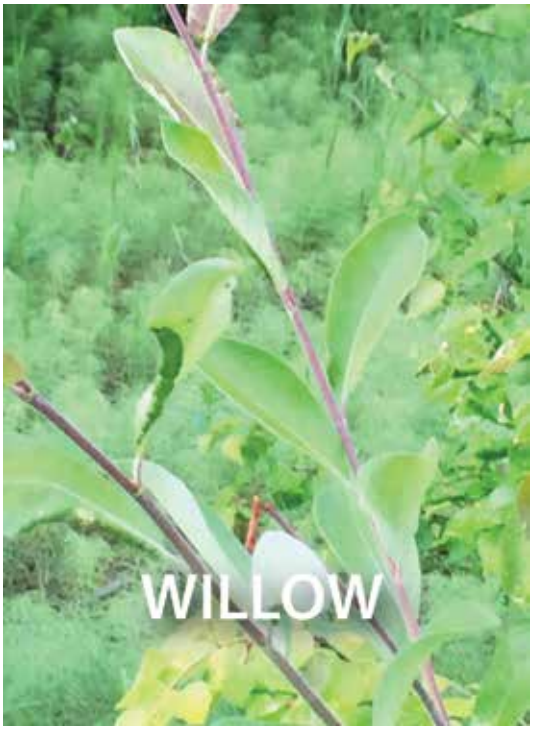
5. Make copies of the Word Games Instruction Sheet (one per group) and the Shrub Expansion Vocabulary worksheet (one per student).

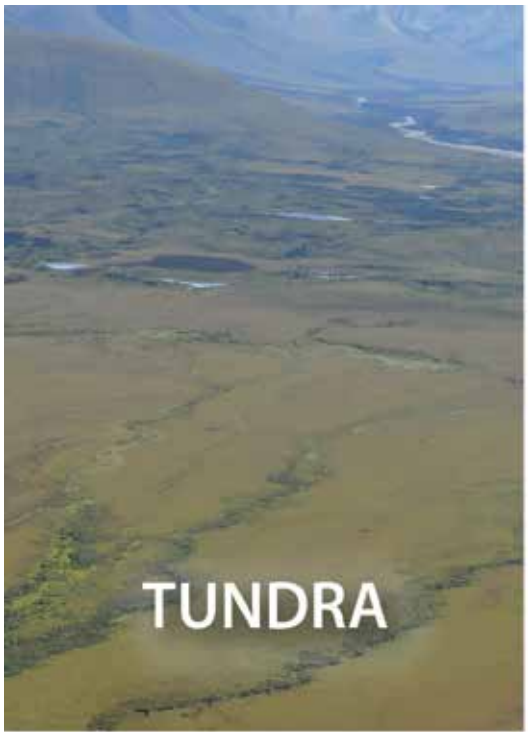
Activity Procedure

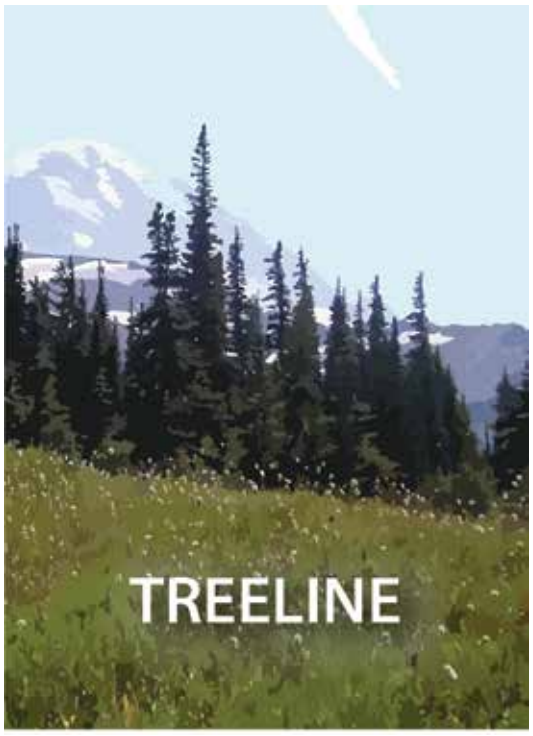
1. Distribute the Shrub Expansion Student Guide and review pages 1-5.
2. Show students the vocabulary cards. Hold up each card. Discuss what each card depicts. How do these terms relate to vegetation in their region?
3. Say the English and local Alaska Native Language word for the illustration depicted on the card. Ask students to repeat the words. Repeat this once or twice, then ask students to call out the correct words as you hold up each card.
4. Divide the class into four groups.
5. Provide each group with the Word Games Instruction sheet, a set of Vocabulary Cards, dry erase marker, and a timer (optional).
6. Instruct students to label their cards with the local indigenous words. Groups can select one student from the group for this task, or take turns.
7. Direct students' attention to the Word Games Instruction sheet. Students can commit to one game for a period of time or mix and match.
8. Encourage students to play the vocabulary games and practice the vocabulary words during free time throughout the duration of the Shrub Expansion unit. If possible, schedule 10-15 minutes twice per week to practice the vocabulary terms.
9. Write the following terms on the board: shrub, shrub expansion, tundra. Ask students to share definitions for these terms. Refer back to the Shrub Expansion Student Guide as necessary.
10. Distribute the Shrub Expansion Vocabulary Worksheet and ask students to complete it.

Vocabulary Cards









Vocabulary Cards

_____ Local indigenous word	_____ Local indigenous word
_____ Local indigenous word	_____ Local indigenous word

Student Information Sheet: Word Games Instructions

VOCABULARY SWAP:

1. Distribute one card to each person.
2. Practice the word on your card, then find a classmate. Teach them the word on your card and learn the word on their card. Trade cards.
3. Find another classmate and repeat.

FIND THE CARD:

1. Divide into small groups. Each group will need a set of vocabulary cards. Spread the cards in front of you so that everyone in your group can see the pictures.
2. Listen as your teacher says a word aloud from one of the cards.
3. Work with your group to find and hold up the correct card.

VOCABULARY SLAP:

1. Select one student to serve as the "caller" for this game. That student should make a list of the vocabulary words on a separate sheet of paper. The words can be found on the back of the cards.
2. Place the cards in a circle, picture-side-up, in the middle of the playing area.
3. The caller should call out a word from their list. Everyone else should quickly place their hand on the picture that they believe represents that word.
4. Turn over the card or cards that students selected to see who chose correctly. Each student who placed his or her hand on the correct card earns a point.
5. Put the card(s) back in the circle and play again.
6. Play for a designated period of time. At the end of the time, the person with the most points wins.

TEAMWORK:

1. Divide your group into two teams. Each team will need a pencil and paper.
2. Shuffle the vocabulary cards and stack them picture-side up in the middle of the table.
3. Work with your team to write down the local Alaska Native Language terms for the picture on the card.
4. After both teams have written answers for the top card, turn the card over to check. Teams get 1 point for the correct Alaska Native Language word.
5. Repeat until all cards are gone. The team with the most points wins.

Student Worksheet: Shrub Expansion Vocabulary

Name:_____

1) Draw a line connecting each definition to the term that it represents.

shrub	a cold and dry biome that is characterized by short vegetation such as grasses, mosses, and lichens
shrub expansion	the northward and upslope encroachment of trees and shrubs into tundra-dominated areas
tundra	a woody plant smaller than a tree, usually having multiple permanent stems branching from or near the ground

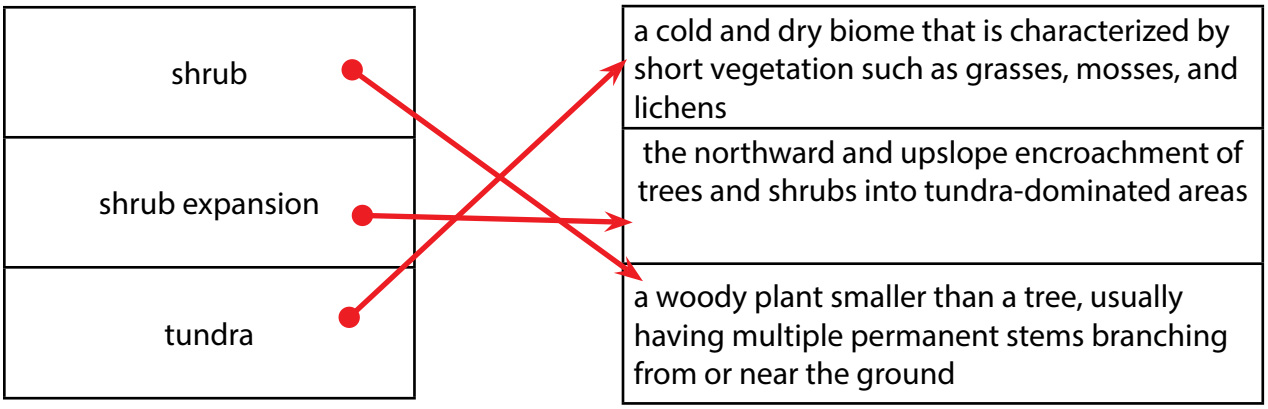
2) Complete the chart by writing the local Alaska Native Language terminology and illustrating the missing terms.

My Community: _____

English Word	Local Alaska Native Language Word	Illustration
shrub		
willow		
tundra		
treeline		

Answer Key:

1)



2)

My Community: _____

English Word	Local Alaska Native Language Word	Illustration
shrub	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
willow	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
tundra	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
treeline	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.

Activity MS.5.3: Quantifying Shrub Expansion

Overview

In this lesson students will analyze repeat photography for evidence of shrub expansion.

Objectives

On successful completion of this lesson, students will be able to:

- identify images used for research as lateral, oblique, or aerial
- define the terms qualitative and quantitative
- explain how vegetation in their region is changing due to climate change
- list positive and negative effects of shrub expansion

Next Generation Science Standards

Standards by Disciplinary Core Ideas: Ecosystems: Interactions, Energy, and Dynamics

Standards by Topic: Matter and Energy in Organisms and Ecosystems, Interdependent Relationships in Ecosystems

Performance Expectations

The activity is just one step toward reaching the performance expectations listed below:
MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. .

Dimention:

Science & Engineering Practices
Constructing Explanations and Designing Solutions

Disciplinary Core Ideas
LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)

Crosscutting Concepts
Stability and Change

Alaska Standards

Alaska Science Standards / Grade Level Expectations

SA1. The student demonstrates an understanding of the processes of science by:

[8]SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating

[8]SA1.2 collaborating to design and conduct repeatable investigations, in order to record, analyze (i.e., range, mean, median, mode), interpret data, and present findings.

SE2. The student demonstrates an understanding that solving problems involves different ways of thinking by:

[6]SE2.2 comparing the student's work to the work of peers in order to identify multiple paths that can be used to investigate a question or problem.

[7] SE2.2 comparing the student's work to the work of peers in order to identify multiple paths that can be used to investigate a question or problem.

[8] SE2.2 comparing the student's work to the work of peers in order to identify multiple paths that can be used to investigate and evaluate potential solutions to a question or problem.

Alaska Cultural Standards

[E] Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them. Students who meet this cultural standard are able to:

[E.2] understand the ecology and geography of the bioregion they inhabit

Bering Strait School District Scope & Sequence

6.9G Understand how ecosystems change over time.

6.9I Use scientific processes and inquiry to directly support concepts of ecosystems and resources in ecosystems

7.1C Interpret topographical maps to identify features (rivers, lakes, mountains, valleys

Materials

- *Shrub Expansion* Middle School Student Guide
- Student Worksheet: *Shrub Data Sheet*
- Transparency sheet with grid template (one per pair of students)
- Magnifying glass (optional - one per pair of students)

Additional Resources

- 2012 Glencoe / McGraw Hill Life Science Textbook, Chapter 22
- 2012 Glencoe / McGraw Hill Life Science Textbook, Chapter 1
- Scientific American Frontiers, Season 14, Episode 4 – *Hot Times in Alaska*, Accessed from: www.chedd-angier.com/frontiers/season14.html

Activity Preparations

1. Makes copies of the *Shrub Data Sheets* and the transparency grid sheets, if needed. To ensure the grid is the correct size to line up with the images in the student guide, make sure you select 'Actual Size' on your printer settings.

Activity Procedure

1. As a class, review the introductory information in the *Shrub Expansion* Middle School Student Guide on pages 1-3.

   The following is a list of shrub expansion benefits and problems your students may identify during your class discussion. If students miss items from the list, guide the discussion so students consider more of these potential impacts:

   - More photosynthesis means less carbon dioxide, less greenhouse effect
   - More firewood for heating homes
   - More habitat for moose and songbirds
   - Less habitat for caribou and upland shorebirds
   - Less visibility for hunting
   - Less berry plants
   - Decreased albedo effect (taller plants are darker than snow/bare ground and absorb more solar energy)
   - Increased risk of wildfires
   - Bark beetle infestation for black spruce
2. Next read and discuss the *Greening of the Arctic* article on pages 6-7 of the student guide. Introduce the activity by having students analyze the featured images.

Figure 1 was featured in *The Changing Arctic Landscape* by Ken Tape. The photos were taken from ground level in the Jago River Valley in Alaska. The old photo is from a collection of photos taken by Ed Sable and George Kunkel for a USGS expedition. Ed Sable gave the collection to Ken Tape for use in his repeat photography project. The camera

positions are nearly identical in the two photos, but in the new photo willow shrubs have replaced alpine flora and are obscuring the ponds and many boulders seen in the old photo. Other boulders have migrated down slope.

Figure 2 photos can also be found in *The Changing Arctic Landscape* by Ken Tape. They are examples of oblique photography, taken from a helicopter along the Chandler River, on the North Slope of Alaska. The old photo was taken July 4, 1948, as part of the geologic reconnaissance in the Naval Petroleum Reserve No. 4, now the National Petroleum Reserve-Alaska. The new photo is from July 28, 2001.

Figure 3 was compiled by plant ecologist and remote sensing specialist Gerald "JJ" Frost. All three photos are from the same area near the Andreafsky River in the Nulato Hills region. (If you are interested in looking up the exact location on Google Earth with your students, the coordinates are 62.340, -162.889 or N62°20"24", W162°53'20".) The 1951 image is an aerial photograph taken from a B-17 plane, as part of a U.S. Navy project. The 1980 image is an infrared photograph taken from a U2 plane, for NASA's Alaska High Altitude Photography Program (AHAP). The 2014 image is a satellite image, courtesy of Digital Globe, Inc, using a Worldview-2 satellite.

3. Guide students in a discussion about designing an investigation to quantify the changes in shrub cover. First make sure students understand that qualification means describing and quantification means assigning a numerical value to something. One can reinforce the other. Explain that the lateral and oblique photos are valuable for observing and qualifying the changes; the aerial photos are more useful for calculating the percent shrub cover and therefore will work better for quantifying the changes.

Middle School 2012 Glencoe McGraw Hill Physical Science Textbook	
Qualitative data	The use of words to describe what is observed in an experiment. (p. NOS 24)
Quantitative data	The use of numbers to describe what is observed in an experiment. (p. NOS 24)

4. Introduce the activity of page 8 of the student guide. Assign partner groups. One student will be the estimator, and the other student will record the data by circling their partner's percentage estimates for each grid square on the data sheet. (Alternatively, you could have them use wet-erase markers and write their percentage estimates directly on the grid.)

5. Distribute transparency grids, data sheets, and magnifying glasses (optional). Students will use the images included in the student guide to compare shrub cover in the Nulato Hills area in 1951 and in 2014. Circulate and assist students as needed.
6. Discuss students' findings. You may want to record each partner group's answers and calculate the class average, to have a larger sample size. Discuss why a larger sample size is desirable in science, especially in cases such as this one where the data collection method is subjective. Compare the findings for the Nulato Hills area to what has been observed in your local community.

Extenstion Activities

- Show the video *Hot Times in Alaska*: Scientific American Frontiers, Season 14, Episode 4. Available online at: www.chedd-angier.com/frontiers/season14.html.
- It is an hour-long program, hosted by Alan Alda and featuring Alaskan scientists who study climate change. The segment about Ken Tape's research on shrub expansion using repeat photography begins at 43:50.
- Scissors-and-Scale Method: Before GIS software was available for analyzing shrub cover in aerial photographs, some scientists used the following approach. Print out the aerial photographs, trace around the darkened areas, and cut those areas out. Weigh the "paper shrubs". Do the same for an image with more shrubs, and there will of course be more "paper shrubs" on the scale. Use the ratio of the difference in weights to calculate the percent change in shrub cover.
- In REACH 6th Grade Lesson #9 "What are Biomes?", students graph the elevation of treeline at different latitudes from north to south. Available at www.k12reach.org/grade6year2.php.
- *Introduction to Repeat Photography Lesson*, Julia West, Polartrec, 2013. Available at: https://www.polartrec.com/resources/lesson/an-introduction-to-repeat-photography

References

Tape, Ken. (2010). *The Changing Arctic Landscape*. University of Alaska Press.

	A	B	C	D	E	F
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Student Worksheet: Shrub Data Sheet

Name _____

Work with a partner. One partner will be the estimator, and the other partner will be the data recorder.

Estimator: Line up the borders of the transparency grid with the image. Looking at one square at a time, estimate the percentage of shrub cover. In other words, what percentage of the grid square is darkened: 0%, 25%, 50%, 75%, or 100%? Work square by square, row by row, starting at the top and working left to right. Tell your estimate to your partner.

Data Recorder: Circle the percentages your partner calls out. Keep track of which row and grid square your partner is on.

1951 Image

A1	0%	25%	50%	75%	100%	**A2**	0%	25%	50%	75%	100%
B1	0%	25%	50%	75%	100%	**B2**	0%	25%	50%	75%	100%
C1	0%	25%	50%	75%	100%	**C2**	0%	25%	50%	75%	100%
D1	0%	25%	50%	75%	100%	**D2**	0%	25%	50%	75%	100%
E1	0%	25%	50%	75%	100%	**E2**	0%	25%	50%	75%	100%
F1	0%	25%	50%	75%	100%	**F2**	0%	25%	50%	75%	100%

A3	0%	25%	50%	75%	100%	**A4**	0%	25%	50%	75%	100%
B3	0%	25%	50%	75%	100%	**B4**	0%	25%	50%	75%	100%
C3	0%	25%	50%	75%	100%	**C4**	0%	25%	50%	75%	100%
D3	0%	25%	50%	75%	100%	**D4**	0%	25%	50%	75%	100%
E3	0%	25%	50%	75%	100%	**E4**	0%	25%	50%	75%	100%
F3	0%	25%	50%	75%	100%	**F4**	0%	25%	50%	75%	100%

A5	0%	25%	50%	75%	100%	**A6**	0%	25%	50%	75%	100%
B5	0%	25%	50%	75%	100%	**B6**	0%	25%	50%	75%	100%
C5	0%	25%	50%	75%	100%	**C6**	0%	25%	50%	75%	100%
D5	0%	25%	50%	75%	100%	**D6**	0%	25%	50%	75%	100%
E5	0%	25%	50%	75%	100%	**E6**	0%	25%	50%	75%	100%
F5	0%	25%	50%	75%	100%	**F6**	0%	25%	50%	75%	100%

A7	0%	25%	50%	75%	100%	**A8**	0%	25%	50%	75%	100%
B7	0%	25%	50%	75%	100%	**B8**	0%	25%	50%	75%	100%
C7	0%	25%	50%	75%	100%	**C8**	0%	25%	50%	75%	100%
D7	0%	25%	50%	75%	100%	**D8**	0%	25%	50%	75%	100%
E7	0%	25%	50%	75%	100%	**E8**	0%	25%	50%	75%	100%
F7	0%	25%	50%	75%	100%	**F8**	0%	25%	50%	75%	100%

A9	0%	25%	50%	75%	100%	**A10**	0%	25%	50%	75%	100%
B9	0%	25%	50%	75%	100%	**B10**	0%	25%	50%	75%	100%
C9	0%	25%	50%	75%	100%	**C10**	0%	25%	50%	75%	100%
D9	0%	25%	50%	75%	100%	**D10**	0%	25%	50%	75%	100%
E9	0%	25%	50%	75%	100%	**E10**	0%	25%	50%	75%	100%
F9	0%	25%	50%	75%	100%	**F10**	0%	25%	50%	75%	100%

Total # times 0% was circled: ___ x 0 = _____

Total # times 25% was circled: ___ x 25 = _____

Total # times 50% was circled: ___ x 50 = _____

Total # times 75% was circled: ___ x 75 = _____

Total # times 100% was circled: ___ x 100 = _____

Total _____ / 60 grid squares

= _____ Estimated percent shrub cover

2014 Image

A1	0%	25%	50%	75%	100%	**A2**	0%	25%	50%	75%	100%
B1	0%	25%	50%	75%	100%	**B2**	0%	25%	50%	75%	100%
C1	0%	25%	50%	75%	100%	**C2**	0%	25%	50%	75%	100%
D1	0%	25%	50%	75%	100%	**D2**	0%	25%	50%	75%	100%
E1	0%	25%	50%	75%	100%	**E2**	0%	25%	50%	75%	100%
F1	0%	25%	50%	75%	100%	**F2**	0%	25%	50%	75%	100%
A3	0%	25%	50%	75%	100%	**A4**	0%	25%	50%	75%	100%
B3	0%	25%	50%	75%	100%	**B4**	0%	25%	50%	75%	100%
C3	0%	25%	50%	75%	100%	**C4**	0%	25%	50%	75%	100%
D3	0%	25%	50%	75%	100%	**D4**	0%	25%	50%	75%	100%
E3	0%	25%	50%	75%	100%	**E4**	0%	25%	50%	75%	100%
F3	0%	25%	50%	75%	100%	**F4**	0%	25%	50%	75%	100%
A5	0%	25%	50%	75%	100%	**A6**	0%	25%	50%	75%	100%
B5	0%	25%	50%	75%	100%	**B6**	0%	25%	50%	75%	100%
C5	0%	25%	50%	75%	100%	**C6**	0%	25%	50%	75%	100%
D5	0%	25%	50%	75%	100%	**D6**	0%	25%	50%	75%	100%
E5	0%	25%	50%	75%	100%	**E6**	0%	25%	50%	75%	100%
F5	0%	25%	50%	75%	100%	**F6**	0%	25%	50%	75%	100%
A7	0%	25%	50%	75%	100%	**A8**	0%	25%	50%	75%	100%
B7	0%	25%	50%	75%	100%	**B8**	0%	25%	50%	75%	100%
C7	0%	25%	50%	75%	100%	**C8**	0%	25%	50%	75%	100%
D7	0%	25%	50%	75%	100%	**D8**	0%	25%	50%	75%	100%
E7	0%	25%	50%	75%	100%	**E8**	0%	25%	50%	75%	100%
F7	0%	25%	50%	75%	100%	**F8**	0%	25%	50%	75%	100%

A9	0%	25%	50%	75%	100%	**A10**	0%	25%	50%	75%	100%
B9	0%	25%	50%	75%	100%	**B10**	0%	25%	50%	75%	100%
C9	0%	25%	50%	75%	100%	**C10**	0%	25%	50%	75%	100%
D9	0%	25%	50%	75%	100%	**D10**	0%	25%	50%	75%	100%
E9	0%	25%	50%	75%	100%	**E10**	0%	25%	50%	75%	100%
F9	0%	25%	50%	75%	100%	**F10**	0%	25%	50%	75%	100%

Total # times 0% was circled: ___ x 0 = _____

Total # times 25% was circled: ___ x 25 = _____

Total # times 50% was circled: ___ x 50 = _____

Total # times 75% was circled: ___ x 75 = _____

Total # times 100% was circled: ___ x 100 = _____

Total _____ / 60 grid squares

= _____ Estimated percent shrub cover

Conclusion

1. According to your estimate, the shrub cover in the image area increased by what percent between 1951 and 2014?

2. Have you heard elders or community members talk about changes in the shrub cover? If so, what have they said about it?

3. How is the landscape near your community similar to the Nulato Hills area? How is it different?

Answer Key: Shrub Data Sheet

Sample answers provided. The estimation activity is subjective, however, if students are consistent with their estimations, their conclusion should reflect approximately 20% increase in shrub cover.

1951 Image

Total # times 0% was circled: 25	x 0 =	0
Total # times 25% was circled: 21	x 25 =	525
Total # times 50% was circled: 7	x 50 =	350
Total # times 75% was circled: 6	x 75 =	450
Total # times 100% was circled: 1	x 100 =	100

Total 1,425 / 60 grid squares

= 23.75 Estimated percent shrub cover

2014 Image

Total # times 0% was circled: 12	x 0 =	0
Total # times 25% was circled: 18	x 25 =	450
Total # times 50% was circled: 13	x 50 =	650
Total # times 75% was circled: 11	x 75 =	825
Total # times 100% was circled: 6	x 100 =	600

Total 2,525 / 60 grid squares

= 42 Estimated percent shrub cover

Answer Key: Shrub Data Sheet

Sample answers provided.

Conclusion

1. According to your estimate, the shrub cover in the image area increased by what percent between 1951 and 2014?

   18% increase

2. Have you heard elders or community members talk about changes in the shrub cover? If so, what have they said about it?
   Yes, I interviewed a community member about changes in shrub cover, and the speakers in the REACH Up video also discussed it. They all said that there are more shrubs than there used to be and also that the shrubs are getting taller.

3. How is the landscape near your community similar to the Nulato Hills area? How is it different?

   The landscape here is flatter than Nulato Hills. Our community is closer to the ocean. The vegetation here is similar to Nulato Hills though. We have mostly tundra with some willows and other shrubs, which is the same as the Nulato Hills area.