Nature's Design: Systems, Cycles, Patterns, Relationships, and Adaptations in the Garden System
Theme 4: Curriculum Map – Grades 6–8

Strand	Topic	Learning Outcomes	Garden Activities	Classroom Extensions	Common Core ELA	Common Core Math	NGSS	NHES
Food	The plant nutrient cycle: carbon cycle, nitrogen cycle, N-P-K, and minerals in plant growth	Recognize the components of nutrient cycles and their interrelationships. Healthy/vital soils = healthy/vital foods = healthy vital bodies. Know where, how and why to apply soil amendments such as compost and mulch to ensure that soils and foods are nutrient rich. Understand and use nitrogen-fixing cover crops as a part of the cycle of building soil fertility in the garden.	Research and plant cover crops that enhance soil fertility. Use these nitrogen-fixing cover crops as a green manure when preparing a bed for planting. Examine the roots of nitrogen-fixing crops, identify the nitrogen nodules on roots and describe the symbiotic relationship of the plants with the soil bacteria.				MS-LS2-3: *Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.* MS-ESS2-1: *Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.*	
	The Soil Food Web: a complex living system of organisms in the soil and their interactions with each other, the environment, plants and animals	Compare and contrast soils rich with fungus, bacteria, and invertebrates (FBI) with soils that are not. Identify the abiotic components in soil that support the soil food web (i.e. carbon, water, air). Recognize that the health of the soil food web impacts the health of the soil. Healthy/vital soils = healthy/vital foods = healthy vital bodies	Design a side-by-side experiment using at least two beds with different kinds of amendment. (no compost or compost) . Observe and record data from control and treatment beds. Interpret the data and present results. Design an experiment using three distinct parts of the garden (compost, path, bed). Lay a transect line, randomly sample along the transect lines using a quadrat.		CCSS ELA-Literacy.SL.8.4: *Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.*	All 6.SP 7.SP.A.1 7.SP.A.2 7.SP.B.3 7.SP.B.4 8.SP.A.1 8.SP.A.2 8.SP.A.3 8.SP.A.4	MS-LS2-4: *Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.* MS-ETS1-2: *Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*	

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			Observe and record quantitative and qualitative data such as plant and insect diversity within each quadrat. Analyze and interpret the data. Present findings using graphs, illustrations and oral arguments.					
	Growing systems in Hawaiʻi: Indigenous, conventional, aquaponics, hydroponics, agroforestry, permaculture, organic gardening * See Appendix: *Native Planters*	Experiment with several different types of growing systems and soil mediums. Keep records of properties and qualities including taste, cost, human labor to build and maintain the systems. Examine characteristics of canoe crops and how they are well-adapted to the environment in Hawai`i.	Design and implement one or more types of growing systems. Collect data. Compare with other growing systems. Evaluate for health and production of biomass.			All 6.SP 7.SP.A.1 7.SP.A.2 7.SP.B.3 7.SP.B.4 8.SP.A.1 8.SP.A.2 8.SP.A.3 8.SP.A.4	MS-ETS1-1: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.* MS-ETS1-2: *Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*	
Energy and Matter	Energy cycles in the garden system	Understand that the sun is the source of energy for all things on the planet. Photosynthesis provides the basis for the food chain. Compare and contrast organisms in the garden and other ecosystems.	Design an experiment where students analyze the effects of different amounts of light on germinated seedlings. Plant 2 rows of lettuce or root crops some with shade-cloth others without. Compare and contrast the difference. Measure temperature in compost and graph heat over stages of	Estimate, calculate and record volume.		All 6.SP 7.SP.A.1 7.SP.A.2 7.SP.B.3 7.SP.B.4 8.SP.A.1 8.SP.A.2 8.SP.A.3 8.SP.A.4	MS-LS1-6: *Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.* MS-LS1-5: *Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.*	

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			decomposition. Infer heat is a byproduct of the processes of cellular respiration of bacteria. Observe how ambient temperature affects the movement of macroorganisms in the garden.					
Energy and Matter	The Food Web trophic levels and proportional relationships of producers to consumers, carrying capacity and population equilibrium Relationship between producers and consumers and effect on habitat	Investigate proportional relationship between producers and consumers and how they dictate carrying capacity in garden systems. Understand consumption of energy along the food chain. Food is made up of energy and matter that are passed from one organism to another. A higher population of consumers is possible when consuming lower on the food chain. For example: eating chicken eggs vs. eating a chicken; (in a year a chicken will lay 300 eggs, vs. 1 chicken body providing 6-8 meals). Analyze the impact of invasive species on diversity of ecosystems and recognize its impact on carrying capacity. Evaluate the	Identify producers, consumers, tertiary consumers and decomposers in the garden. Observe, count and record number of plant species in two distinct locations in the garden - one with invasive species and one without. Evaluate population diversity and analyze abundance. Observe and collect data of volume in a compost pile over time. Relate findings to availability of resources. Discuss carrying capacity for fungi, bacteria, and invertebrates (FBI).	Play "Oh! Deer". Keep track of population size on a graph. Follow up questions to consider: Which species do/do not follow dynamic equilibrium? http://www.riverventure.org/charleston/resources/pdf/population study game.pdf Respiration in yeast activity. • Activate yeast and sugar; • use digital Vernier probes to analyze the pH of the gas generated to show evidence of carbon dioxide and respiration. • Students blow air through a straw into BTB solution (pH indicator) to demonstrate carbon dioxide's ability to turn liquids acidic.		7.G.B.6 8.G.C.9	MS-LS2-2: *Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.* MS-LS2-1: *Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.*	

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Energy and Matter		interdependence of organisms on environmental resources and how they affect population size.						
	Forms and transformation of energy, conservation of energy • potential • kinetic (thermal) • chemical	Recognize that humans are an intrinsic part of energy transfer in the garden. Identify energy transformation in the forms of potential, kinetic (thermal), and chemical in the garden. Assess changes in matter (garden products) that occur as a result of processing (e.g., by cooking, fermenting, making compost teas).	Kinesthetic activity: “Plants build the sugars up, humans break them down.” Use cooking as a model for evaluating and measuring the kinetic energy of objects. Higher temperature = greater kinetic energy. Fill different colored hand-washing tubs with water at the beginning of class. Leave them in the sun and compare the temperatures at the end of class.				MS-LS1-7: *Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.* MS-PS3-4: *Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.*	
	Chemical and Physical Changes in the Garden System and Classroom Kitchen	Examine ingredients from the garden before processing or cooking and make predictions about physical and chemical changes. Examine finished product and check accuracy of predictions about physical and chemical changes in the ingredients.	Design an experiment for solar heating of water, use different colored materials as an independent variable and compare temperature from beginning and end of class. Boiling and freezing of substances to demonstrate changes of states of matter and the relationship between kinetic and	Design solar ovens and dehydrators.			MS-PS3-3: *Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* MS-PS3-4: *Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the*	

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Energy and Matter			thermal energy. Observe sun, wind and water patterns in the garden and link to potential energy sources. Use solar ovens to cook foods. Mixtures: Create a mixture of salt and pepper. Emulsify salad dressing. Physical change: cutting foods. Chemical: Oxidation of fruits and vegetables.				*temperature of the sample.*	
	Fossil Fuels and Renewable Energy Inputs, outputs, and the transformation of energy Examples: Compare a tractor, a rototiller, and a garden fork to cultivate a garden bed. Use of a solar pump vx. And electric pump for a hydroponic system. (Discussion Topic)	Identify where Hawai'i's energy comes from. Critique different models for generating electrical energy: renewable, fossil fuels, nuclear, etc. Critique may include: cost, human labor to build and maintain the systems. * See Appendix: Kokua Foundation's nutrition lesson skit.	Compare a tractor, a rototiller, and a garden fork to cultivate a garden bed. Compare use of a solar pump or an electric pump for a hydroponic system. (Discussion Topic)	Compare and contrast organic lettuce from your garden and pre-washed and bagged organic lettuce. Look at appearance, cost , human labor, miles travelled, fossil fuel involved, freshness and taste.			MS-ETS1-2: *Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.* MS-ESS3-4: *Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.*	
Water	The Water Cycle and its interrelationship with weather and climate The properties of water	Recognize the cyclical pattern of air and water movement on Earth and identify these patterns in the garden. Observe water in the	Research water sources in garden. Collect rainwater. Keep a rain gage and log of rainfall in your garden. Note seasonal trends. Compare your			7.SP.B.3 7.SP.B.4	MS-ESS3-1: *Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.*	

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		garden and contemplate that this water is the same water as when Earth began. *See Appendix: "The Earth is an Apple."	numbers to the best data you can find for your area. Notice what parts of the water cycle you can witness, find evidence in your garden.				MS-ESS2-4: *Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.*	
	The action of water in living systems.	Use water in the garden as diluter, solvent, transporter, insulator, diffuser. (water can be used in any of its forms)	Create an example of watering through capillary action over time using a string and bucket. Use water as a diluter when applying worm or compost tea and soil amendments.			6.RP.A.1 7.RP.A.3	MS-ESS2-4: *Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.* MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*	
	The hydrology of Hawai'i Island drinking water (This is a topic for discussion in the garden)	Investigate freshwater resources for your garden and how they are a result of the island's' geological processes and formations (e.g., Where does your water come from?). Assess the renewability/future availability of this resource in the garden.	Identify the role plants play in the water cycle, using transpiration bags as evidence. Observe wind patterns in the garden and identify seasonal trends. Keep a rain gage and log of rainfall in your garden. Note seasonal trends. Compare your numbers to the best data you can find for your area.	Construct and use models and labs to demonstrate the effects of Earth's rotation and convection currents on wind and weather patterns. (Model of Earth's water cycle) Identify water sources and illustrate the path for our drinking water.			MS-ESS2-4: *Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.* MS-ESS3-1: *Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.*	
	Water Storage, Sources, and Management	Recognize water sources in the garden. Evaluate where water	Construct and implement various irrigation systems and record effects on				MS-LS2-5: *Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*	

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		is needed in the garden and design irrigation systems. Eliminate standing water as vector for disease: * See Appendix: "Fight the Bite." Department of Health	garden ecosystems (e.g., soil salinification, plant growth). Compare irrigation systems efficiency in terms of water conservation (e.g., drip irrigation or overhead watering).				MS-ETS1-1: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.* MS-ETS1-2: *Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*	
Natural resources management and conservation	Water conservation and management	Know that fresh water is a finite resource. Recognize that each individual has a role to play in water conservation. Understand impacts of community conservation efforts. Understand the garden is part of an entire watershed. Recognize appropriate use and limitations of greywater and county water.	Identify practices at school and at home that conserve water. Utilize grey water in garden systems for plants. Examine impacts of home and garden practices on water systems. Create a catchment system to mitigate effects of treatment of county water (chlorine off-gassing).	Measure water quality in various areas in the school community. Assess impact of water quality on salt and freshwater ecosystems. Label storm drains: Drains to Ocean potable non potable run off Identify point and nonpoint sources for pollution in the community.		6.RP.A.3.B 7.RP.A.2.B 8.EE.B.5	MS-ESS3-4: *Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.* MS-ETS1-1: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.* MS-ETS1-2: *Evaluate competing design solutions using a systematic process to determine how well they*	

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Natural resources management and conservation							*meet the criteria and constraints of the problem.*	
	Water Quality	Analyze water systems in the garden and design improvements for greywater use. Maintain a water system using potable and non-potable water correctly (e.g., use potable water for processing garden products).	Utilize grey water in garden systems for plants. Examine impacts of home and garden practices on water systems. Create a catchment system to mitigate effects of treatment of county water (chlorine off-gassing). Know that water is a vector for contaminants and examine inputs and outputs in garden water systems. Recognize the potable and non-potable water sources in your garden. Understand the distinctions between potable and non-potable water, and the health implications. Experiment with water quality. Compare and contrast how different water sources impact garden (e.g., rain water vs. municipal in garden uses).	Investigate how and where water is treated, processed and reused in your geographical area. Investigate the safe uses of greywater in the garden. Assess impact of water quality on salt and freshwater ecosystems.		6.RP.A.3.B 7.RP.A.2.B 8.EE.B.5	MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* MS-ETS1-1: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.* MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	

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	Local sources of organic nutrients for soil fertility	Identify and utilize local resources for soil fertility(e.g., use paper as carbon for compost). State the difference between the bi-products of organic vs. inorganic materials as they decompose. Know how to build a layered compost with organic matter from the garden and paper recourses. Identify paper as a carbon source. Identify green plants as nitrogen. Build aerobic compost piles using correct proportions of carbon and nitrogen in layers. Recognize weeds can be used as a source of nitrogen in compost.	Collect, weigh and record discarded organic materials (e.g., shredded paper, foods) from school and apply to compost system. Examine debris from the garden plants and identify how it is used in the garden ecosystem. Identify and explore sources of organic nutrients on your school campus and within your community that can be used for building soil fertility systems (e.g., mulching, composting). Use these resources. Apply diverse types of mulch to the garden. Design, create and maintain a zero waste system that uses paper to make soil, soil to grow food and food to feed school community. Use the slogan, "Feed the Soil and the Soil Feeds You."			6.SP.B.4 6.SP.B.5.A 6.SP.B.5.B 6.SP.B.5.C 6.SP.B.5.D	MS-ETS1-1: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.* MS-ETS1-2: *Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.* MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* MS-ESS3-4: *Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.* MS-LS2-3: *Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.* MS-LS1-5: *Construct a scientific explanation based on evidence for how*	NHES: 3.8.1, 3.8.3, 5.8.1, 5.8.2, 5.8.3, 5.8.4, 5.8.5, 5.8.6, 5.8.7

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							environmental and genetic factors influence the growth of organisms.	
Natural resources management and conservation Natural resources management and conservation	Recycling, upcycling, and downcycling of inorganic materials	State the difference between the bi-products of organic vs. inorganic materials. Recognize that inorganic materials have different rates of decomposition and persist over time. Think critically about results and impacts of consumer choices, including the bi-products from consuming food, processing and packaging, recognizing that “Zero Waste” as a goal.	Collect, weigh and record discarded organic materials (ex: shredded paper, foods) from school and apply to compost system. Compare and contrast the volume, mass, and reusability of packaging from various sources. Design, create and maintain a zero waste system that uses paper to make soil, soil to grow food and food to feed school community. Use the slogan, “Feed the Soil and the Soil Feeds You.” Compare and contrast the volume, mass, and reusability of packaging from various sources. Make and label decomposition timeline of discarded products with real examples. Reuse and repurpose materials in the garden. Make and use a 4R (Refuse, reduce, recycle, reuse) or Zero waste system	Analyze food byproducts (eg. packaging) from various sources such as the grocery store, farmers market and garden. Design a 4R (Refuse, reduce, recycle, reuse) or Zero waste system for your garden			MS-ETS1-1: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.* MS-ETS1-2: *Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.* MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* MS-ESS3-4: *Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems.* MS-LS2-3: *Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.*	NHES: 3.8.1, 3.8.3, 5.8.1, 5.8.2, 5.8.3, 5.8.4, 5.8.5, 5.8.6, 5.8.7

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			for your garden				MS-LS1-5: *Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.*	
Natural resources management and conservation	Components of air quality	Identify how the garden can be a solution for human energy consumption practices impacting air quality.	Observe systems in the garden that produce clean energy (e.g., photosynthesis, solar pumps, weed mat).	Using a pH indicator solution, such as BTB, have students use straws to blow carbon dioxide into the solution. Pour the solution into test tubes. Place a sprig of Elodea in each test tube and leave overnight underneath painter's lamps. Leave at least one test tube with only solution and no Elodea as a control. Check the next day. Solution should show that it has become less acidic (oxygen replaced carbon dioxide, changing the solution from yellow to greenish-blue).			MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* MS-ESS3-5: *Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*	
	Carbon footprint and Carbon sequestration	Understand, describe, and interpret the carbon footprints of human activities and their impact on air quality.	Identify practices in the garden that impact the carbon footprint.				MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* MS-ESS3-5: *Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*	

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Natural Resources Management and Conservation	Sources and impacts (air water and soil) of clean energy in the community	Define carbon footprint. Explain garden systems that sequester carbon. * See Appendix: "Carbon footprint survey"	Build compost piles to sequester carbon.				MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* MS-ESS3-5: *Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*	
Best Conservation Practices	The individual's role in the conservation of natural resources Conservation: a set of practices that preserve, restore, and protect natural resources and ecosystems	Interpret data from the garden about renewable and nonrenewable resources. Recognize garden systems that preserve, restore, and/or protect non-renewable resources (e.g., saving water). Identify various sources of mulch. Compare and contrast local and non-regional historical, cultural, and/or archeological conservation practices.	Collect and interpret data from the garden about renewable and nonrenewable resources. Design garden systems that preserve, restore, and/or protect non-renewable resources (e.g., saving water). Identify, collect and use sources of mulch. Compare and contrast local and non-regional historical, cultural, and/or archeological conservation practices in your garden.				MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* MS-ESS3-5: *Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*	
Best Conservation Practices	Preserve, repair, and prevent deterioration of the environment, topsoil, water, and natural resources Invasive species	Understand "Zero Waste" as a goal. Design a 4R system for your garden (Refuse, reduce, recycle, reuse).	Implement a 4R or Zero Waste system in your garden.				MS-ETS1-2: *Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*	

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	Waste is a system out of balance	Design and implement a "Zero Waste" system for your garden. Identify the impacts of invasive species. Recognize that there are management practices for invasive species.	Manage and dispose of invasive species in your garden and on your school campus.	Make public service announcement or flyer for your community about an invasive species in your area and how to manage it (e.g., tiny fire ant, or coqui frog).			MS-ETS1-1: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.* MS-LS2-5: *Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*	