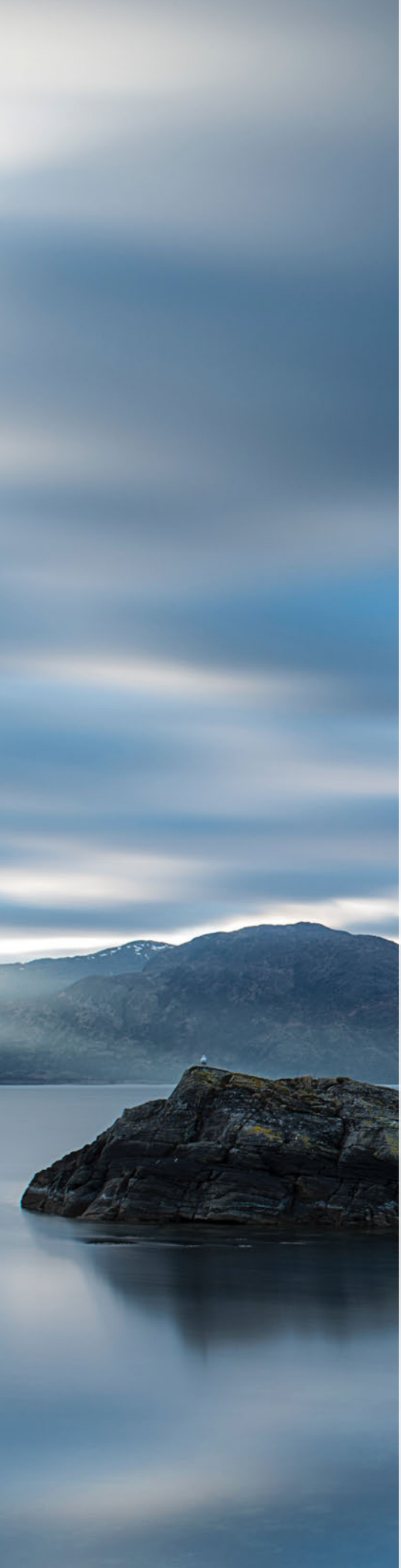
COMPREHENSIVE REPORT

ACHIEVING CLIMATE STABILITY AND ENVIRONMENT SUSTAINABILITY

PK–12 EDUCATION
AS PART OF THE SOLUTION
FOR BENDING THE CURVE

UC–CSU Environmental and Climate Change Literacy Project and Summit (ECCLPS) is a partnership between the University of California (UC) and the California State University (CSU) systems with key stakeholders to support the urgent need to advance PK–12 environmental and climate change literacy.



Faculty and administrative leaders of education from the University of California (UC) and California State University (CSU) systems are partnering with key stakeholders to support the urgent need to advance pre-kindergarten to high school environmental and climate change literacy.

By the UC–CSU Environmental and Climate Change Literacy Project and Summit (ECCLPS) Steering Committee

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AS HOST OF THE CONVENING OF THE

Environmental Climate Change Literacy Project and Summit

UCLA acknowledges the Gabrielino/Tongva peoples as the traditional land caretakers of Tovaangar (the Los Angeles basin and So. Channel Islands). As a land grant institution, we pay our respects to the Honuukvetam (Ancestors), ’Ahiihirom (Elders), and ’Eyoohiinkem (our relatives/relations) past, present, and emerging.

STRATEGIC SUMMARY

ACHIEVING CLIMATE STABILITY AND ENVIRONMENT SUSTAINABILITY

PK–12 EDUCATION
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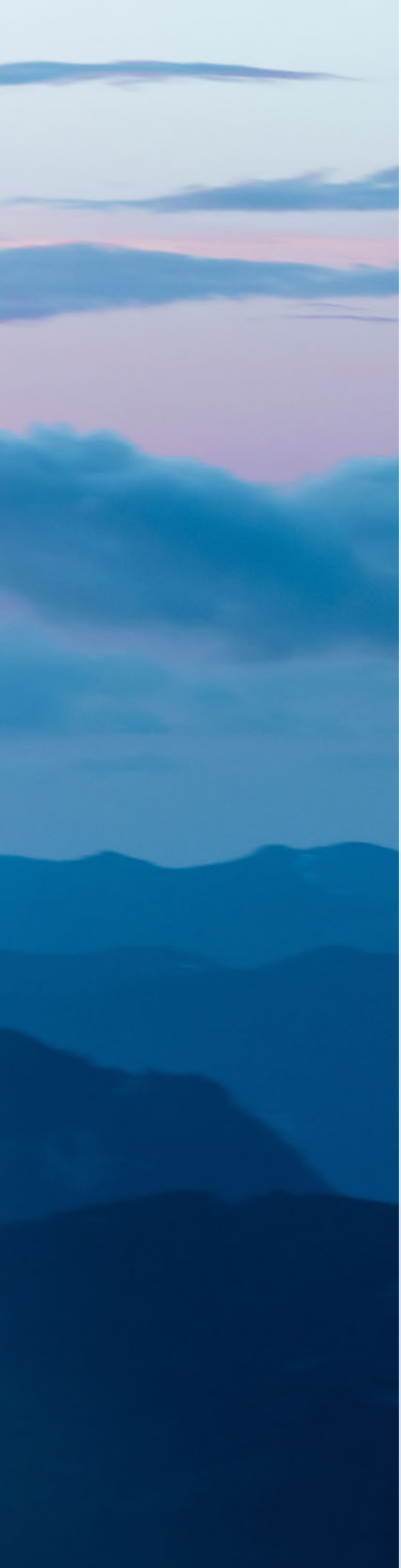


This report identifies innovative as well as practical and scalable solutions to prepare current and future teachers to educate students in California so that they are literate in environmental and climate change solutions and become stewards of our planet.

OUR GOAL

We are a coalition of educators, scientists, environmentalists, non-profit agencies, universities, teacher educators and teachers seeking to support and collaborate with key stakeholders on scaling up PK–12 education initiatives around environmental and climate change literacy in our state so that the youth of California become climate champions, educated and fully capable of tackling climate change and environmental disruptions now and moving forward.

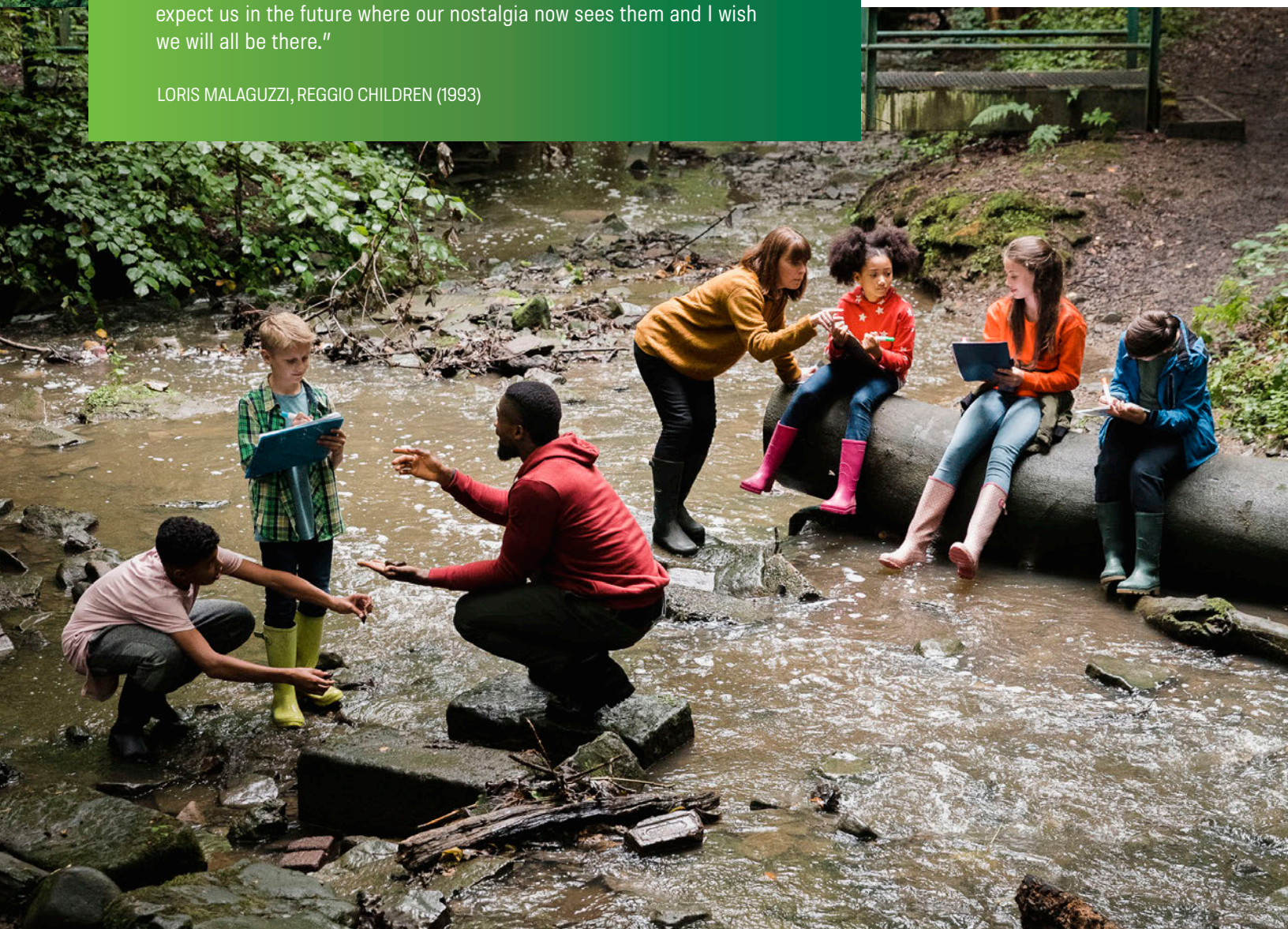
We are creating a large coalition of like-minded individuals, organizations, and educational institutions to develop the educational foundation our young people need to succeed as 21st Century environmental activists and as global citizens. This **UC–CSU Environmental and Climate Change Literacy Project and Summit (ECCLPS) Strategic Summary** shines a light on the pioneering work that is being done statewide and the ways in which we can support, refine and expand the implementation of environmental and climate change literacy moving forward. Developing climate change literacy and the capacities and motivation required to make real change to our impact on the natural systems that sustain us. We aim to accomplish this by empowering the collective 500,000 high school students who graduate each year in California. We seek to significantly expand the opportunities of every child in California to learn about climate change and to have the tools to affect positive social action.

With unchecked climate change and the alarming rate of environmental degradation, the right to a sustainable environment is urgently becoming the human rights imperative of our times—and will remain a priority through this century.

BACKGROUND

University of California (UC) and the California State University (CSU) systems train approximately 56% of the Pre-Kindergarten through grade 12 (PK–12) teachers in the state. The formation of ECCLPS by UC and CSU administrators is a clear demonstration of the commitment by the faculty and administrators in UC and CSU to support PK–12 education initiatives in the state around environmental and climate change literacy. ECCLPS is focused on integrating environmental and climate change literacy throughout the PK–12 public education system, with a focus on future and current teacher preparation.

> "We should think that we have more need of being nostalgic, not so much about the past but more nostalgic about the future. The children expect us in the future where our nostalgia now sees them and I wish we will all be there."
>
> LORIS MALAGUZZI, REGGIO CHILDREN (1993)



NEED FOR ENVIRONMENTAL AND CLIMATE CHANGE LITERACY

We live in an ever more interconnected, miniaturized and fragile world. Unsustainable consumption of fossil fuels and other natural resources and the waste produced by this continually growing consumption pathway is the fundamental cause for polluting the air, the water, and the land. As the U.S. EPA found in 2007,* the current and projected concentrations of the six key greenhouse gases—including carbon dioxide, methane, and others—in the atmosphere threaten the public health and welfare of current and future generations. This pollution of the planetary climate and ecosystem has unleashed two catastrophic forces: climate disruption and species extinction, both of which pose existential threats to all of humanity and the ecosystems. In short, *Homo sapiens* have become a geologic force. We are likely now living in a new era, the Anthropocene. The environmental crisis we face requires a fundamental societal transformation.

Education must be one of the pillars and part of the solution to support such a transformation. Education must start from PK–12 and continue through adulthood.

In addition to ECCLPS, there are at least two other major climate education initiatives in which UC and CSU are collaborating. The University of California (UC) is a public university system with ten university campuses and a student population of more than 280,000, which has created the Carbon Neutrality Initiative as well as its spin-off, *Bending the Curve: Climate Change Solutions*. The Bending the Curve project has created a system-wide undergraduate education protocol, Climate Change Solutions, which is now being licensed by select universities in the U.S., Sweden and East Asia. The Climate Change Solutions course is now being taught at one CSU campus and in discussion to take it system-wide at the California State University system of 23 campuses with a student population of at least 481,000. CSU and UC faculty have independently started a UC–CSU Knowledge to Action Network (UC–CSU KAN) to promote climate change education in California and beyond. Faculty and staff in UC and CSU are uniquely positioned to equip youth with the 21st Century skills required for a sustainable planet. ECCLPS will facilitate in this educational partnership that will also include school educators and teachers as partners and leaders.

*https://www.epa.gov/ghgemissions/endangerment-and-cause-or-contribute-findings-greenhouse-gases-under-section-202a-clean

YOUTH ARE OUR FUTURE

Empower environmentally literate high school graduates, numbering over 500,000 each year, to become stewards of our planet.

The challenges we are facing as a global society and the solutions proposed will be accelerated by our youth, who, when equipped and given the opportunity, can be powerful change makers within their communities. In fact, teenagers are pioneering youth movements across the world to fight climate change. Millions of young climate and environmental champions are needed to fight this battle, armed with knowledge and tools for bending the (carbon) curve. We must begin now and educate these champions starting at the Pre-K level and continuing through college.

We will seek participation from state experts in the PK–12 education space to surmount environmental challenges. Our reach is global—for the global commons has to work together to solve the crisis we have created over the last two centuries. However, our immediate focus for the summit and this report will be on California.

Our collective goal is to empower environmentally literate high school graduates, as many as 500,000 per year, by amplifying and refining current efforts, commencing new initiatives, making connections amongst current initiatives and programs throughout the state and nationally, and develop strategic solutions based on the recommendations in this report and with input from the summit attendees. It is our expectation that the summit and this report will serve as a catalyst for bringing in state and national climate change and education leaders, students, PK–12 education experts, higher education leaders, private foundations investing in education, Non-Governmental Organizations (NGOs), and non-formal education leaders with these specific objectives of the report:

- Facilitate a state-of-the-art, practical, and scalable environmental and climate change literacy plan for pre-service and in-service teachers, and ultimately for PK–12 students, designed to support their leadership and civic engagement
- Increase awareness and understanding of environmental issues, particularly climate change and climate disruptions, and innovative as well as practical and scalable ways to bend the curve
- Promote behavioral changes and societal transformation towards sustainability and mitigation of climate changes

In September, the CSU and UC systems' leadership signed onto a declaration of a climate emergency sponsored through the UN, underscoring the need for a drastic societal shift to combat the growing threat of climate change.

"What we teach shapes the future. We welcome this commitment from Universities to go climate neutral by 2030 and to scale-up their efforts on campus. Young people are increasingly at the forefront of calls for more action on climate and environmental challenges. Initiatives which directly involve the youth in this critical work are a valuable contribution to achieving environmental sustainability."

INGER ANDERSEN
EXECUTIVE DIRECTOR
UN ENVIRONMENT

Youth Movements for Climate Mitigation

Thirty percent of the world's population is under 18. In the long-term they will be most impacted by climate change the world over. The youth are leading the charge for environmental activism in inspiring and successful ways. They have led climate strikes and protests, created organizations and spearheaded new work at the local, national and international levels. They are speaking to Congress and to the UN. Their convictions are clear. Their voices are strong. They exemplify collective empowerment and positive social action.

FRIDAY FOR FUTURE In 2018, Greta Thunberg led the first ever Friday for Future in Stockholm, Sweden. She was protesting inaction on climate change in front of the Swedish parliament. This began the Friday for Future movement and inspired millions of young students around the globe to take action on adult inaction on climate change.

GLOBAL CLIMATE STRIKE FOR FUTURE On March 15, 2019, school strikes, urging adults to take responsibility and stop climate change, began taking place in over 2,000 cities worldwide. An estimated number of 1.4 million pupils from around the world participated in the events.

Demonstrations happened across the U.S. in Ann Arbor, New York City, Portland, Washington DC, San Francisco, St. Paul, Los Angeles, Chicago, Seattle, Boston, and Sacramento with an estimated 17,000 student participants who left school to attend the marches. Their objectives included protesting inaction on climate change; demanding that governments take immediate climate action; and mobilizing voters to show politicians there is strong demand for taking bold action on climate.

EXTINCTION REBELLION On April 22, 2019 (Earth Day), Extinction Rebellion was held in Los Angeles and New York, Quebec City, London, Cologne, Berlin, Paris, and Sydney. The organizing group is using nonviolent civil disobedience to protest against climate change; demand that governments tell the truth about climate change; and advocate for citizens' assemblies to oversee climate policies and zero carbon emissions by 2025.

U.S. YOUTH CLIMATE STRIKE On May 3, 2019, the U.S. Youth Climate Strike took place in hundreds of schools in over 20 cities around the country. U.S. Youth Climate Strike demands include: Green New Deal; a halt in fossil fuel infrastructure projects; scientific-research led decisions made by the government; declaring a National Emergency on Climate Change; obligatory comprehensive education on climate change impacts and climate justice for K–8; preserving public lands and wildlife; and keeping the water supply clean.

On September 19, 2019, the **Global Climate Strike** was likely the largest climate strike to date and included over 4 million people worldwide, including students from an estimated 156 countries ahead of the UN Climate Summit.

OUR PLANET TODAY

With unchecked climate change and air pollution, the very fabric of life on Earth, including that of humans, is at grave risk.

PONTIFICAL ACADEMY OF SCIENCES DECLARATION, 2017

The planet has already warmed by 1.1°C (2°F) since pre-industrial times, and this warming has created new weather extremes. From 1995 to 2015, extreme weather events have left 4.1 billion persons across the globe injured or homeless or in need of emergency assistance and in addition have claimed 605,000 lives. Gross acreage burned in California has increased by 400% since the 1970s, and forest fires by 700%. Alarmingly, we now learn, the decades ahead will see a sudden steepening of that escalation.

For the poorest three billion of Earth's population, 2°C (3.6°F) of global warming, expected before 2050, would pose catastrophic existential threats, in effect raising an unprecedented intra-generational equity issue, which will become worse as it lingers for centuries affecting generations unborn.

In the first quarter of the 21st Century, the world witnessed the largest number of forcibly displaced human beings in history. While precise numbers are both elusive and changing 2019 United Nations High Commissioner for Refugees data report that more than 70 million people—the equivalent of every man, woman, and child in Lagos, São Paulo, Seoul, London, Lima, New York, and Guadalajara—are escaping home into the unknown. While migration is a shared condition of humanity, it is increasingly catastrophic: "The majority of new displacements in 2016 took place in environments characterized by a high exposure to natural and human-made hazards, high levels of socioeconomic vulnerability, and low coping capacity of both institutions and infrastructure" (IDMC, 2017).

EQUITY AND CULTURAL RELEVANCE

With unchecked climate change and the forward kinetic movement of environmental degradation, the right to a sustainable environment is urgently becoming the human rights imperative of our times—and will remain a priority moving forward through this century. Fifty to sixty percent of the world's climate pollution is due to the wealthiest one billion on the planet, while the poorest three billion have negligible impact on the climate. Yet the poorest will suffer the worst consequences of the climate change caused by the wealthiest. The ethics of social justice and equity considerations must be at the forefront of a new education agenda in California and beyond.

A 21st Century environmental sustainability education must first be:

- Relevant to local concerns while embedded in a larger global ethic of solidarity, equity and care.
- Developmentally appropriate (how a five-year-old thinks about air pollution and how a ten-year-old thinks about climate change will differ among other things by socio-emotional and cognitive readiness to internalize and process facts, concepts and ideas).
- Culturally as well as developmentally appropriate knowledge, values, sensibilities, and practices required to participate effectively within multiple, nested ecologies (regional, national, and transnational), environments, and communities while understanding, valuing, and respecting cultural differences.
- Rooted in the realities of historic and systemic environmental injustices that must be understood and addressed to make progress toward equity.
- Focused on teacher and student inquiry, agency, leadership, and civic activism.

It is by nurturing socio-emotional learning, the values and virtues of engaged citizenship, and by imparting the basic skills to prepare youth for a changing world that schools become meaningful vehicles for collective empowerment and positive social action. All our schools must endeavor to inculcate in children and youth humane sensibilities, empathy and perspective taking, communication and collaboration skills, higher-order cognitive skills for critical thinking, as well as the metacognitive abilities to become lifelong learners, civic agents and environmental champions.

AN EDUCATIONAL NARRATIVE FOR THE FUTURE— THE SUSTAINABLE PLANET

We endeavor to propose an educational narrative building on the idea of the sustainable planet. Our starting point will be the child's innate moral sensibilities and the natural and emerging scientific curiosities of youth. It should build on their solidarity, providing a sense of connection to peers in one's local environment and community as well as with youth from around the world. The sustainable planet serves to expand the sense of "me" into "us" and the "us-vs-them" into the "us-with-them group." It endeavors to provide a compelling moral imperative that can set youth on an active search for Bending the Curve solutions to interrupt and reverse harmful disruptions in their environment. And it will serve to spur agency and engagement with the practices of science, engineering, public health, civic engagement, policy and planning in youth. Above all, we will expand the opportunities for every student to learn about climate change and to act on what she is learning effectively and for the common good.

EXPAND THE SENSE OF "ME" INTO "US" AND THE "US-VS-THEM GROUP" INTO THE "US-WITH-THEM GROUP"

TRANSFORMATIVE ENVIRONMENTAL EDUCATION— THE MAJOR CHALLENGE

Climate change is a politically charged topic. Even though teaching climate change is supported in California, it poses unique challenges to teachers because of the mixed and politicized messages in the broader culture. Despite decades of international collaboration, in 2017 the United States announced that it is pulling out of the UN Paris Agreement of 2015.

All is not lost however. Many states like California are entering into sub-national climate action plans to follow emission reduction targets that can keep the warming under 2°C.

In addition to being politicized, climate change is also an emotionally charged topic, and there is often a lack of clear guidance about the appropriate way to broach the issue with children of different ages. Without accessible and effective resources, climate change can slip through the cracks of educators in favor of more palatable and less fraught issues. Fortunately, as a result of California's standards, frameworks, and *Blueprint for Environmental Literacy*, work is under way to cultivate a more inclusive movement for environmental literacy which will illuminate climate change as the shared existential crisis and humanitarian opportunity it truly is.

The most important myth to debunk is that there is not scientific consensus about the phenomena of climate change and its human causes.

RECOMMENDATIONS

The approaches we took to arrive at the following recommendations are aligned with California's environmental education goals, current efforts underway by the California Environmental Literacy Initiative (CAELI) and the state's climate action policies. This Strategic Summary and the Comprehensive Report were developed and synthesized by three ECCLPS subcommittees: 1) Pre-service, which addresses the preparation of future teachers; 2) In-service, which addresses the continued support and learning of current teachers; and 3) Curriculum, which addresses the course of study for all our students. The subcommittees were convened by the ECCLPS co-chairs and led by key educators and stakeholders across the state.

We turn then to the overarching recommendations from all three subcommittees.

OVERARCHING RECOMMENDATIONS:

Achieving comprehensive PK–12 environmental and climate change education in the State of California will require action and commitments across many entities at all levels of education.

- **Integrate environmental and climate change literacy across all subjects.** This can be achieved by ensuring teacher and educational leader preparation programs include robust understanding of California's Environmental Principles and Concepts (EP&Cs) and the scientific concepts and facts of climate change and sustainability with content across all PK–12 disciplines. Because solving the climate crisis will require systems thinking, UC and CSU faculty can play a key role by modeling boundary crossing between the natural sciences, social sciences, arts and humanities in undergraduate and graduate education. This step will enable the development of PK–12 educators and leaders who can work across barriers in policy and practice.
- **Recommend that the state of California create a Taskforce for the Promotion of Environmental and Climate Change Literacy.** The Taskforce will partner with and build on the significant momentum of the work of the California Environmental Literacy Initiative (CAELI) which was convened to implement California's *Blueprint for Environmental Literacy*. The Taskforce will bring together relevant stakeholders in the CSU, UC, and community college systems to develop an implementation plan for achieving comprehensive PK–12 environmental and climate change literacy education focused on pre-service and in-service professional learning. The implementation plan will be based on the recommendations in this report.

- To maintain the momentum of the convening while the Taskforce is being created, ECCLPS will **create a Post-Summit Steering Committee** to prioritize the recommendations in this report and develop strategies for implementation.
- **The California Commission on Teacher Credentialing (CTC) will further refine and update opportunities for current pre-service teachers** to integrate California's EP&Cs into the core subjects they will teach and learn the most up-to-date scientific, ethical and social justice work on climate change. The CTC is a valuable potential mechanism for change, since it ensures that teacher and educational leader preparation programs focus on environmental and climate change literacy content across all PK–12 content areas.
- **Earth Science is an indispensable discipline to holistically approach the issues at stake.** There is currently work underway to incorporate this messaging and we support those efforts. Moving forward, we suggest that A-G requirements could include a third year of high school science and also add Earth Science as an A-G science class option.

Educating Future Teachers: Pre-Service

Achieving comprehensive PK–12 environmental and climate change literacy education in the state of California will require action and commitments at all levels, including: faculty and administrators in colleges, schools or departments of education, academic units in the sciences, social sciences and the humanities as well as faculty from across the disciplines whose graduates enter teacher preparation programs; the Commission on Teacher Credentialing; leaders of relevant state and private educational institutions and initiatives.

1. The proposed efforts should endeavor to align with existing initiatives to leverage resources and build capacity for implementing the report's recommendations at the system-wide, institutional, and individual level. Examples of existing initiatives include:

- UC–CSU Knowledge Action Network for Transformative Climate and Sustainability Education and Action
- UC-CSU NXTerra
- Bending the Curve: Climate Solutions education protocol developed by over 50 faculty from UC and now taught at UC and CSU campuses, two-year colleges in the state, Stockholm University and Taiwan National University
- CSU-wide Course Redesign with Technology program
- CSU Mathematics and Science Teacher Initiative
- The California Subject Matter Project
- Campus as a Living Lab Programs
- Faculty learning communities and professional development opportunities housed and supported by the Centers for Teaching and Learning on college campuses
- Student and teacher serving organizations under the umbrella of UC Student Academic Preparation and Educational Partnerships (SAPEP)
- UC San Diego Social Sciences initiative focused on climate crisis

2. The Taskforce should advocate the use of technological tools and resources to access educational materials including climate and environmental data. The Taskforce should also prioritize connections with community partners and other teacher preparation providers in the creation and dissemination of these resources. Such connections to be made in collaboration with the California Department of Education and California Environmental Literacy Initiative to ensure pre-service teachers have the optimal tools at their disposal to engage students on climate change learning.

Educating Current Teachers: In-Service

The recommendations below address ways that teachers can be supported through professional learning opportunities, classroom and curricula setup and practices, and more. All recommendations are related to and build off each other to provide a more comprehensive framework for teachers to succeed in teaching environmental and climate change literacy.

1. Increase teacher confidence in environmental and climate change literacy. It is necessary that all teachers feel confident, empowered, and supported to integrate environmental concepts and principles into their standards-based curriculum. Teachers need the skills and resources to advocate for the prioritization of environmental and climate change literacy with administrators, school board members, parents, and members of the community.

2. Promote a fully scaled state-wide system for high quality teacher professional learning around California's Environmental Principles and Concepts (EP&Cs). Effectively scaling the system would require professional learning by the educators already in the system (and no longer doing coursework through UC or CSU).

3. Obtain administrative support for environmental and climate change literacy in schools. There needs to be administrative support at all levels (i.e., site, district, county, state, pre-service) so environmental and climate change literacy becomes a priority at broader structural levels. Administrators need to advocate for the prioritization of environmental and climate change literacy for teachers, school board members, parents, and community members.

4. Emphasize action and civic engagement as part of environmental and climate change literacy. Teaching about the environment and climate change should include examples of how people have fought for and against policies that affect the health of people and the planet. Proven practices for civic education include learning about policies, practices, and current events in addition to service learning, community engagement, and school governance.

5. Create interdisciplinary learning models across different subject areas. Environmental and climate change literacy should be taught from multiple perspectives and through multiple disciplines for students to not only understand the science of natural systems but also learn about the ethical, social, historical, and geographic aspects of human interactions with the environment.

Educating Our Students: Curriculum Modernization

The primary recommendation is for the UC and CSU systems to support, localize, and help grow existing climate education efforts at the PK–12 levels.

1. Pre-service methods courses for elementary teachers and in secondary subjects should endeavor, whenever possible, to expose student teachers to state-of-the-art environmental and climate change literacy. The development of rigorous new learning opportunities for climate change literacy for the next generation of California teachers is both academically sound and pragmatically smart.

2. In-service professional learning offerings for practicing teachers could **strategically convene educators and relevant local working groups or community networks to re-examine and localize PK–12 course offerings**. At the high school level, the foci should be on helping educators innovate as they incorporate climate change content into A-G approved courses in every subject and in expanding the number of Career and Technical Education (CTE) courses in environmentally related sectors available to students.

The following five principles are the basis for our recommendations in the development or modification of any curriculum for teaching about climate change to students.

- Curricula should teach climate change as expressed in California's Next Generation Science Standards and California Science Framework with explicit connections to California's Environmental Principles & Concepts.
- Non-science curricula should teach climate change via connections to California's Environmental Principles & Concepts and as outlined in California's adopted frameworks in History-Social Science and Health.
- Curricula should introduce and provide teachers and students the opportunities to explore real-world phenomena through outdoor and environmental place-based experiences, participate in problem-based learning, and apply engineering design strategies to solve real-world problems.
- To engage and empower students, curricula should encourage and inspire students to play a significant role in culturally relevant community issues in an integrated, interdisciplinary, and developmentally appropriate way to support student voice, activism, and action.
- The teaching of climate change needs to be coherent and coordinated across school, home, and community experiences.

SUPPORTING OUR TEACHERS

A possible concern with the recommendations in our report is the perception of an additional burden on our teachers. We have been very careful, both in the report and in work already underway related to environmental and climate change literacy, to not add anything extra to a teacher's workload and instead we have organized to support teachers to become familiar and comfortable with current and emerging standards and frameworks by illuminating a path focused on this particular topic.

As outlined in this report, California's PK–12 science standards (CA NGSS) already include climate change as a topic of study. California's science framework (2016), history-social science framework (2016), and health framework (2019) include California's Environmental Principles and Concepts (EP&Cs), which, as of 2018 (SB720, Allen), specifically include climate change and environmental justice as topics of study. Teacher preparation programs are already required by the California Commission on Teacher Credentialing (CTC) to instruct new teachers in how to implement these standards and frameworks.

The foundations are indeed in place; however, state mandates do not translate to action without both support and accountability. Achieving the aspirational climate-related goals set out in our recommendations requires that teachers more skillfully integrate information about human and natural systems into sophisticated cross-curricular inquiries and solution-oriented projects. The UC and CSU systems have a crucial role to play in building capacity for these pedagogical shifts. Subject matter faculty can provide the content expertise that teachers need. Education faculty can provide time, space, and guidance for teachers to design learning experiences, and administrators to support climate-change-related learning sequences that maximize instruction by helping students meet multiple standards at once. The UC and CSU systems are crucial partners in co-creating an up-to-date, concretely local curriculum and coordinating professional learning opportunities that increase the number of teachers skilled in problem-based and civically-engaged pedagogies at the heart of California's vision of globally competent, environmentally literate learners and leaders.

FOUNDATIONAL CALIFORNIA INITIATIVES

The stated objectives and outcomes above are ambitious but we are not starting from a blank slate. California's climate change literacy work is being built on decades of solid educational policy and investments. California's legislature and various agencies have uniquely articulated the need for PK–12 students to develop environmental literacy as part of a coherent, standards-based curriculum. Our initiative endeavors to support, expand, update, and refine the current work underway; including building upon the following:

Education and the Environment Initiative

Assembly Bill 1548 (Pavley, 2003) launched the Education and the Environment Initiative by mandating the creation of a multi-agency partnership to develop California's Environmental Principles and Concepts (EP&Cs) and develop a model curriculum that demonstrates how to integrate the EP&Cs into standards-based instruction for all K–12 students. The State Board of Education approved the EP&Cs in 2004.

Blueprint for Environmental Literacy

In 2014, former State Superintendent of Public Instruction, Tom Torlakson, launched a taskforce to write a Blueprint for Environmental Literacy. The Blueprint, published in 2015, is a call to action for the education community to educate every California student in, about, and for the environment. The guiding principles for taking this work to scale are equity of access, sustainability and scalability of systems, collaborative solutions, commitment to quality, cultural relevance and competence, and exposing students to a variety of learning experiences in classrooms and outdoor environmental settings.

In 2016, Torlakson formed a steering committee, which is now operating as the California Environmental Literacy Initiative (CAELI) and leading the work in PK–12 by advocating for a supportive state context, supporting the incremental infusion of environmental literacy into the PK–12 instruction, professional learning, assessment, and accountability infrastructure, and cultivating leading-edge district and county office of education exemplars.

California Regional Environmental Education Community (CREEC) Network

The California Regional Environmental Education Community (CREEC) Network fosters regional partnerships throughout the State of California to promote environmental education and environmental literacy by providing teachers with access to high quality professional learning opportunities and education resources. It is a program of the California Department of Education.

Integration of EP&Cs into the state curriculum frameworks

California's State Board of Education (SBE) has demonstrated its commitment to environmental literacy by calling for the integration of the EP&Cs into state curriculum frameworks in Science (2016), History-Social Science (2016), and Health (2019). SBE-adopted instructional materials in these content areas must integrate the EP&Cs, and the state's California Science Test (CAST) will, in part, use the EP&Cs as a context for assessing California's Next Generation Science Standards (adopted in 2013), for all students in elementary, middle, and high school grade bands. CAST is a part of the state's accountability system.

Codification of California's EP&Cs into the California Education Code

Senate Bill 720 (Allen, 2018) codified California's EP&Cs into the California Education Code as the state's definition of environmental literacy and directed the State Board of Education (SBE), State Superintendent of Public Instruction, district superintendents, and school boards to work toward all students becoming environmentally literate members of society. It also updated the list of covered concepts to explicitly include environmental justice and climate change. By adopting the NGSS, the State Board guided all California educators

to teach about climate change in accordance with the state-adopted standards.

California Science Teachers Association (CSTA) Climate Literacy Summit

In early 2018, the California Science Teachers Association (CSTA) recognized that significant gaps in teacher content knowledge and experience in teaching climate science existed. CSTA, in collaboration with partners from Scripps Institution of Oceanography and the National Aeronautics and Space Administration's Jet Propulsion Laboratory, pioneered the development of a Climate Summit for PK–12 educators and developed grade level units of study aligned to current standards (presented as three-hour short courses), and the production of a special climate edition of the *California Journal of Science Education*. All of the resources developed for this project were made free to the public.

Commitment to teaching the Next Generation Science Standards

In 2015, CSTA published a position paper on climate change and in 2019 published a position statement on environmental literacy encouraging their membership to embrace it as part of their commitment to teaching the Next Generation Science Standards.

CSTA BELIEVES THAT AN ENVIRONMENTALLY LITERATE PERSON:

- Habitually recognizes and acts on the knowledge of how natural and human systems are woven together to produce ecosystem services upon which humans and the natural environment are both dependent.
- Makes decisions informed by environmental science (including traditional ecological knowledge from diverse cultures) and habitually acts to sustain the natural environment for future generations.
- Recognizes that access to high-quality, culturally relevant environmental learning opportunities for every student is a social justice issue and that barriers to environmental learning must be removed via thoughtful collective action and integration into the TK–16 educational system.

CALL TO ACTION

In September 2019, in the largest-ever youth-led demonstrations in history, young people took to the streets by the millions to articulate in hundreds of different languages and in cities big and small, on every continent on Earth, a powerful message: We must act on climate change now. Climate change has ignited the dynamic movement for youth agency and action in service of the common good. To let this new energy go to waste would be a shame. Climate change education for all should be a part of the solution for moving forward.

It is going to take a transformational change in behavior to wean society away from fossil fuels and unsustainable consumption. Education for all is the only way to affect such mass scale behavioral transformation toward a sustainable planet and sustainable humanity.

We aim to expand the opportunities for every student to learn about climate change and to act on what they are learning effectively and for the common good of paving the way for a sustainable planet. It is by nurturing socio-emotional learning, the values and virtues of engaged citizenship, and by imparting the basic skills to prepare youth for a changing world that schools and colleges become meaningful vehicles for collective empowerment and positive social action. Schools and colleges must endeavor to instill in youth humane sensibilities, empathy, communication and collaboration skills, higher-order cognitive skills for critical thinking, as well as the metacognitive abilities to become lifelong learners, civic agents and environmental literacy champions.


ASK NOT WHAT
YOUR PLANET CAN
DO FOR YOU
ASK WHAT YOU CAN
DO FOR YOUR PLANET

ACHIEVING CLIMATE STABILITY AND ENVIRONMENT SUSTAINABILITY

RECOMMENDATIONS
CHALLENGES
SOLUTIONS
AND
RESOURCES

PK–12 EDUCATION
AS PART OF THE SOLUTION
FOR BENDING THE CURVE

ENVIRONMENTAL AND CLIMATE CHANGE LITERACY PROJECT AND SUMMIT

DECEMBER 11–12, 2019
UCLA MEYER AND RENEE LUSKIN CONFERENCE CENTER
LOS ANGELES, CA

This event is sponsored and organized by the University of California, California State University, California Subject Matter Projects, Strategic Energy Innovations, and Ten Strands.

The summit's focus is on highlighting best practices and innovative solutions that prepare future and current teachers to educate 500,000 graduating students per year in California to become literate in environmental and climate change problems and solutions.

The Summary outlines the overarching perspectives, strategies and recommendations from the three ECCLPS Subcommittees: pre-service, in-service, and curriculum. It serves as a high-level summary of the work of the subcommittees.

The following sections offer additional subcommittee recommendations to UC and CSU systems as well as the State; subcommittee chapters including challenges, solutions, bringing the work to scale and examples of best practices; and concludes with substantial environmental and climate change literacy resources compiled by the three ECCLPS subcommittees.

These stakeholders are doing the deep thinking required to address urgent environmental and climate change issues by identifying best practices and next steps for scaling up environmental and climate change literacy, making meaningful recommendations, and suggesting commitments that can be made by the UC and CSU systems and the State in support of educating the youth of California to become literate in environmental and climate change problems and solutions.

The time to act was yesterday. Fortunately, there is still time to both stabilize climate change and minimize species extinction. We must act now.

FOSTERING CONNECTIONS TO SOCIAL JUSTICE

Over the last century, the ethnographic record has made clear that cultural models, sensibilities, and general orientations towards the environment differ substantially across the world. In the future, environmental and sustainability education must foster culturally and developmentally appropriate knowledge, values, sensibilities, and practices required to participate effectively within multiple (regional, national, and transnational) environments and communities while understanding, valuing, and respecting cultural differences. A true and authentic commitment to children—as inhabitants of our planet and agents of environmental stewardship—requires nothing short of an authentic, organic, and sustainable allegiance to the environment.

Teachers must endeavor to foster the knowledge and skills necessary for employment in a sustainable global economy; incorporate multiple relevant cultures, languages, and environmental epistemologies in the classroom; and promote equity pedagogy and engage in culturally relevant and responsive teaching that is at once engaging and significant to the students' local environments and realities. However, to achieve transformative environmental education and to effectively engage within and across the diverse communities of the 21st Century, students need to acquire democratic environmental and civic attitudes, sensibilities, and identities with the capacity to take action.

Environmental and climate change literacy is intimately connected to social justice because human life is interdependent with nature, and environmental changes do not affect everyone equally. Since environmental crises have typically impacted the poor and people of color disproportionately worse than wealthy people and nations, environmental and climate change literacy poses human rights issues, social justice concerns and questions about who is more affected by environmental problems and who is most responsible. Integrating environmental and climate change literacy across content areas provides an opportunity for students, especially those who have been marginalized, to become stakeholders in solving local and global environmental challenges.

According to a recent report on *Equitable Access to Science Education* (2019)[1] by the California Science Teachers' Association (CSTA) "the reality in California, and across the U.S., is that high-quality science education is not yet sufficiently available for all students in all schools. There are persistent gaps in access and achievement for student populations who have been historically underrepresented in science education and careers" because "the root causes of gaps in student participation and achievement are often systemic inequities among schools and districts that result in large

differences in student access to science learning opportunities." Underrepresented students need to see their identities and interests respected and reflected in science education. The Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve (CA NGSS) emphasize phenomena-based, problem-centered instruction, providing many opportunities to honor underrepresented students' identities and foster agency and belonging by connecting academic content to students' home cultures, local communities, and environmental and social justice concerns.

"The CA NGSS call for teachers to facilitate more student-centered, locally relevant learning that enables young people to think on their own, problem solve, communicate, and collaborate, as well as dive more deeply into disciplinary core ideas. For most teachers at all grade levels, shifting to more student-centered, equity-centered pedagogy requires significant new professional learning, more time to redesign curricula and collaborate with other teachers, and additional resources for specialized facilities, equipment, and materials," according to the report. "Major shifts in policy and resources are necessary to increase time for teacher preparation and collaborative planning to provide instruction that fully delivers on the promise."

This ECCLPS report is intended to catalyze the policy and resources shifts that are necessary for higher education faculty, PK–12 educators, and students to develop environmental and climate change literacy and the capacities and motivation required to make real change in our impact on the natural systems that sustain us.

California Environmental Principles and Concepts (EP&Cs)

Principle 1: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

Principle 2: The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.

Principle 3: Natural systems proceed through cycles that humans depend upon, benefit from and can alter.

Principle 4: The exchange of matter between natural systems and human societies affects the long-term functioning of both.

Principle 5: Decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes.

As of 2016, these principles are embedded within the California frameworks for Science, History-Social Science, and Health.

SUBCOMMITTEE RECOMMENDATIONS

These recommendations are offered as additions to the Subcommittee recommendations included in the Strategic Summary.

Recommendations to the UC-CSU Systems

Implicit and explicit policy changes to how higher education prioritizes and supports environmental and climate change literacy will offer support for teachers on the ground and provide incentives for administration and parents to become more interested and committed to better environmental and climate change literacy.

In terms of implicit and explicit policy changes, we offer suggested recommendations to the UC–CSU systems:

- **Leverage Existing Campus Resources**

  UC and CSU systems can invest in collaborating in local working groups of university researchers and instructors from every relevant science and non-science discipline, schools of education faculty, community partners, and PK–12 leaders and teachers to revise existing courses and develop new ones for future and current teachers to better align with the goals already in place. Policies, standards, frameworks, and State Board of Education-approved published curricula exist and there are many national supplemental resources available. In order to teach these curricula, universities play a vital role in building educator content knowledge and pedagogical capacities.[2]

- **Environmental and Climate Change Literacy and Leadership Master's or Certificate Programs**

  Create and offer master's programs or certificate programs that are focused on environmental and climate change literacy and leadership.

- **Revise Research, Tenure, and Promotion (RTP) Policies and Practices**

  Encourage universities to revise their RTP policies and practices to promote cross-curricular programs. For example, encourage environmental science faculty to collaborate with schools of education to develop PK–12 professional learning programs.[3]

- **Pilot Group to Create Model Pre-Service Courses**

  Convene a pilot group to create model pre-service courses that align with these best practices, state standards, and the California Commission on Teacher Credentialing's Teacher Performance Expectations for new teachers.

- **Extension programs for teachers**

  Create and offer extension programs for teachers who want to learn about climate science. These extension programs should include an online option that working teachers can complete remotely and should consider affordability and other incentives to make it easier for teachers to access and complete such programs.

- **Short-term courses for PK–12 educators**

  Create and offer short-term, single courses available for teachers who have limited time and resources, who are looking to brush up on a particular area of climate science or science teaching pedagogy.

- **Convene Pilot Groups to Facilitate the Co-creation of Refined and Localized PK–12 Curriculum**

  Convene pilot groups on four campuses—two UCs and two CSUs—to facilitate the co-creation of refined and localized PK–12 curriculum units among groups of university faculty from hard science and social science departments and PK–12 leaders and teachers to advance teacher in-service professional learning.[4]

- **Create opportunities for university faculty within and beyond colleges of education to engage with PK–12 teachers and students**

  Professional learning providers should collaborate with university faculty to create, provide, and support professional learning opportunities related to environmental and climate change literacy.[5]

- **Share Expectations for Student Competencies related to environmental and climate change literacy**

  PK–12 educators need to know what the expectations are for foundational knowledge and skills related to environmental and climate change literacy in order to appropriately prepare students to enter state colleges and universities. If the UC and CSU articulate and share these expectations, PK–12 educators have a better understanding upon which to build their instructional programs.

- **Update High School Science A-G Requirement**

  Update the high school science A-G requirement for UC eligibility from two to three years. This structural change will help ensure that students dedicate the necessary time to learn about scientific concepts and include Earth science and environmental science in their education.

- **Coordinate with UC–CSUs involved in city planning**

  Loop in PK–12 educators and involve them in local planning work. Advisors from UC–CSUs are often involved in planning initiatives around sustainability, climate change, and environmental justice. Bringing in PK–12 educators offers ideas to educators on how to engage their students and helps address issues that PK–12 educators see at their respective grade levels and communities, while creating opportunities for advisors to connect with and support PK–12 educators and classrooms.

Recommendations to the State

California has built a strong foundation through PK–12 policies and frameworks, as well as natural resource management targets. Achieving comprehensive PK–12 environmental and climate change literacy education in the State of California will require intensified and coordinated action and commitments at all scales, including: The Commission on Teacher Credentialing (CTC), State Board of Education (SBE), the California Environmental Literacy Initiative (CAELI), and California Department of Education (CDE); Taskforce for Promotion of Environmental and Climate Change Literacy; teacher preparation providers, colleges, schools or departments of education; academic units in the sciences, social sciences and the humanities; leaders of relevant state and private educational institutions and initiatives; as well as individual faculty who train future teachers.

- **Update California's Education Code and subsequent earmarked funding to support three years of science in high school**

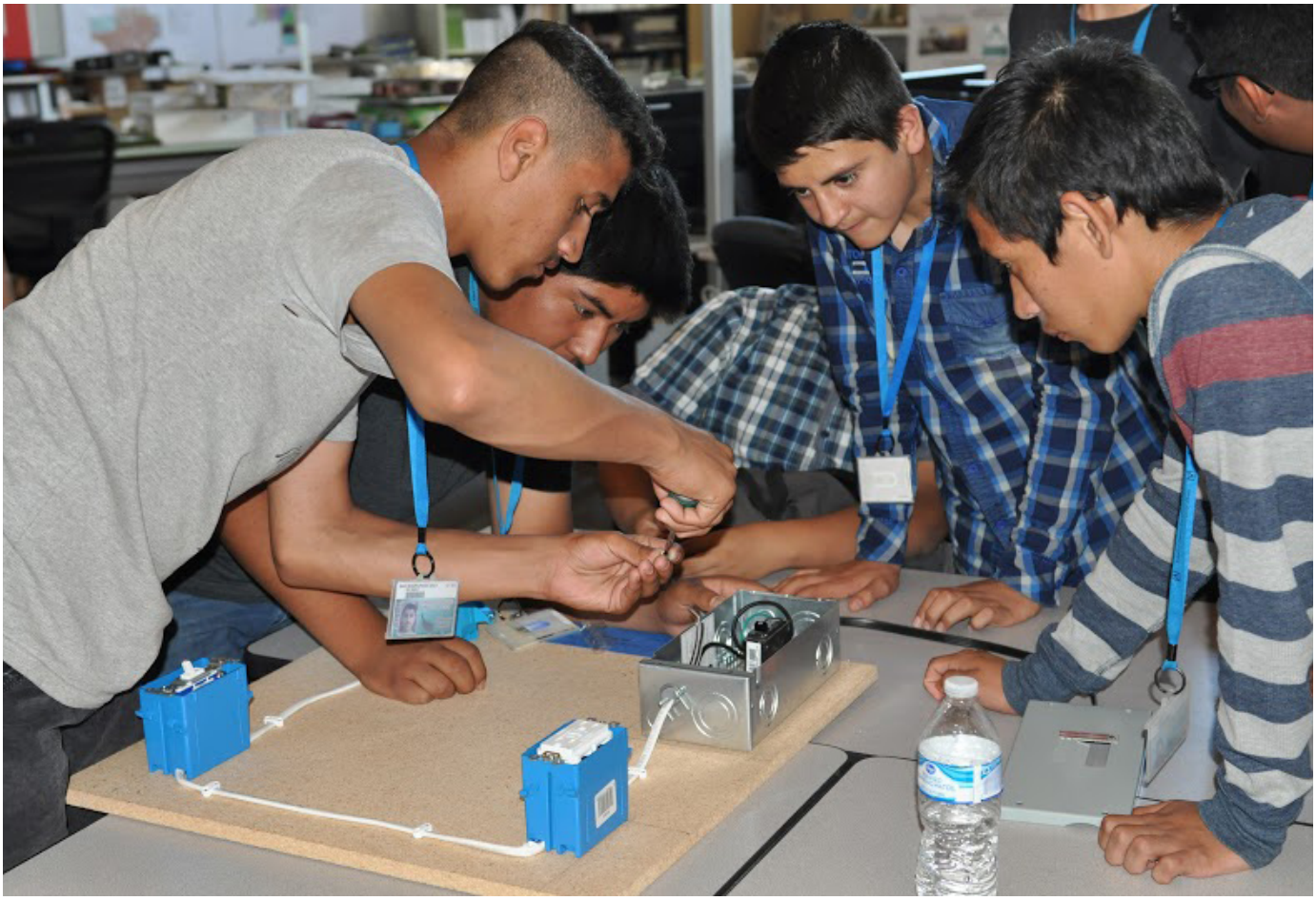
  This would finally make the vision of *All Standards All Students* that the California Next Generation Science Standards (CA NGSS) propose—including inclusion of Earth and Space Science into science courses—a reality for *all* high school students.[6]

- **Maximize the benefits of Local Control Accountability Plans (LCAP)**

  Include specific, targeted funding allocations for environmental and climate change literacy work in Local Control and Accountability Plans (LCAPs). LCAPs provide a natural entry point and source for consistently funding environmental education at the local level. The State Board of Education could take leadership in supporting the California Department of Education in launching an informational campaign around ways districts can effectively embed language in their LCAPs to maximize the amount of federal funding from the Every Student Succeeds Act (ESSA), specifically Title II and Title IVA.[7]

- **Target financial support from the state specifically for the implementation of the new standards and frameworks**

  Numerous financial barriers facing many LEAs have prevented successful implementation of the CA NGSS and other state frameworks. To continue its strong leadership role, the California State Board of Education could request one-time funding from the California State Legislature to fully support the implementation of the CA NGSS and other state frameworks that would also advance environmental and climate change literacy.[8,9]



Additional Subcommittee Recommendations

Environmental and climate change literacy interconnects across all educational content and with all stakeholders. Students work and learn within the ecosystem of their campus and community; therefore, a systems approach should include parents and community, school boards and trustees, unions, nonprofits, community-based organizations, local businesses, and accrediting bodies.

These recommendations are related and build off each other to provide a more comprehensive framework for educators to succeed in teaching for environmental and climate change literacy. They also extend the professional learning recommendations presented for pre-service educators in this report.

- **Leverage existing State resources such as Residency Grants, the Integrated Teacher Education Program (ITEP), and Bilingual Authorization (BLA) grants to promote environmental and climate change literacy education**

  Specifically, the development of ITEP programs explicitly focused on environmental and climate change literacy will improve the education of future teachers in this area while also increasing diversity in the teacher workforce. This is an important component of environmental justice efforts because environmental justice is intimately connected to social justice.

- **Initiate partnerships between educator preparation programs and industry sector identified high school pathway programs participating in Linked Learning**

  This is a California statewide initiative that combines rigorous academics, work-based learning, and career and technical education (CTE) for middle and high school students to prepare them for college and careers. Teachers collaborate across subject areas with input from working professionals and are reinforced using scaffolded work-based learning opportunities provided by real employers culminating in senior design projects.[10]

- **Strategically convene in-service professional learning networks**

  In-service professional learning offerings for practicing teachers should convene educators and rich local working groups or community networks to re-think and localize PK–12 course offerings. At the high school level, the foci should be on helping educators incorporate climate change content into A-G approved courses in every subject and in expanding the number of Career and Technical Education (CTE) courses in environmentally related sectors available to students.[11]

- **Integrate guest speakers, programs, and field studies to engage students in learning about and interacting with the environment**

  These experiences should build upon pre-service learning foundations for teachers and help all students to establish and develop a connection with their local environment, regardless of whether it is rural, suburban, or urban, so that they understand the issues on a personal and contextualized level.[12]

- **Create authentic learning opportunities and models for community collaboration**

  Students can stimulate, apply, and enhance their learning about the environment through real life learning experiences facilitated by their teachers. Focusing on local environmental phenomena and problems is one part of this. Furthermore, job shadowing, internships, project-based learning research, interviews, service learning projects, and volunteer opportunities in community organizations, government agencies, or businesses with “green jobs” are some options to consider in helping students learn about the environment through real-world jobs, issues, and settings. These learning opportunities can and should be connected to students’ academic programs in school and personal experiences.

PRE-SERVICE

The worsening conditions of our climate crisis and the complex nature of environmental and climate change literacy education will necessitate a thoughtful review of teacher preparation programs and support systems in addition to classroom, campus, and administrative culture. Indeed, environmental and climate change literacy by necessity must include education of the head, heart, and hands. A focus on interconnectedness, empathy, compassion, responsibility, civic engagement, critical thinking, leadership, and stewardship of the Earth must be central to the educational content, pedagogy, and culture of the spaces in which students learn for the educational process to empower students to action.

Environmental education is at a crossroads in California and nationwide. While there are notable exemplary practices in environmental education and literacy within California and around the U.S., they are isolated initiatives with no established and sustainable means of sharing resources. As scattered and disconnected entities, their influence for far-reaching and deep impact on improving environmental education and literacy in the state is limited.

Our subcommittee surveyed single-subject and multiple-subject pre-service teacher education programs in the CSU and UC system to identify a set of exemplary practices and direction for future support and coordinated efforts in this area (see Appendix 2.1). Thirty-three programs responded to our survey, representing 14 CSU and 4 UC campuses. Of the survey takers, 94% provided general or specific information to indicate environmental and climate change literacy is addressed in some fashion within the single- and multiple-subject teacher preparation programs on CSU and UC campuses, predominantly during science content/curriculum and instruction courses.

Programs reported that the vast majority of pre-service candidates were exposed to environmental education in their coursework, lesson planning and fieldwork. However, there was less widespread exposure to technological tools, resources and community partners to support work in this area. Overall, 35% of single- and multiple-subject respondents indicate that pre-service candidates use technology to access environmental and climate change literacy resources; fewer than half of the campuses reported having partnered with community organizations to advance training and environmental education efforts. (This survey did not address curriculum covered as part of pre-service teacher education before they enter a credential program. These courses may often be where pre-service teachers are exposed to environmental science and climate change topics but are even more difficult to coordinate since they may take place outside of a single college or school on campus.)

Best Practices

CSU AND UC PRE-SERVICE PROGRAMS WITH EXEMPLARY PRACTICES

We highlight a few examples here to provide a sense of current efforts.

- **CSU Bakersfield and UC Davis' C-STEM Center**

  Along with other community partners (including Tejon Ranch Conservancy and Wind Wolves Preserve), these centers partner to create and offer professional development trainings for teacher candidates and mentor teachers related to the use of technology for the purposes of increasing environmental and climate change literacy (see Appendix 2.2).

  Multiple-subject candidates in the science methods course learn to code and to program sensors, which are used to capture information about local air and water quality. Pre-service candidates also use linkbots and video-making technologies to engage in public-facing storytelling. Pre-service teacher candidates also participate in online citizen science projects and build their capacity for contributing to large-scale data collection, analysis, and environmental policy discourse with their students. Their efforts are supported by a Teacher Quality Partnership grant from the United States Department of Education focused on Citizen Science, with an emphasis on environmental and climate change literacy and associated civic action in K–12 teacher education.

- **CSU San Marcos Elementary Science Education**

  Combining outdoor environmental education with citizen science, cohorts are taken onsite to a local lagoon conservancy for outdoor science and to learn about resource sustainability for the local watersheds and wildlife; classroom lesson plans are created by candidates based on this experience, and candidates are able to choose ecological areas of interest on which to provide real time data to scientists on Zooniverse (Appendix 2.2).

- **UCLA Pre-service Programs**

  Implement projects relevant to students' interests and well-being through project-based learning exercises at the UCLA Community School. For example, this past year they worked on a project examining lead in water to identify Human Impact on the Environment connected to the California Next Generation Science Standards (CA NGSS).

- **CSU Monterey Bay and Monterey Bay Aquarium**

  Create alliances that link universities with informal learning centers and community organizations, such as the partnership of CSU Monterey Bay and Monterey Bay Aquarium (Appendix 2.2) where pre-service teachers have access to relevant professional development knowledge, resources, and activities geared towards regional environmental and climate change literacy and applicable CA NGSS-focused pedagogical practices. Pre-service teachers are formally connected to the Monterey Bay Aquarium's continuing professional development programs. Informally, depending on the mentor

teacher, some pre-service teachers get to engage with public and/or private community organizations through field trips whose focus is on helping PK–12 students develop awareness of the relationship between human impacts and the environment. Example areas of study are: the Elkhorn Slough; homelessness and urbanization; littering, beach access and marine life; and analyses of invasive plant species.

- **CSU Fresno Strategic Teacher Education Partnership (STEP)**

  CSU Fresno has developed the Strategic Teacher Education Partnership (STEP) (Appendix 2.2) which provides interdisciplinary learning experiences for pre-service teachers by placing pre-service undergraduates majoring in Liberal Studies into cohorted courses for a more cohesive and connected interdisciplinary experience. Cohorted courses taught by faculty in their respective disciplines in different departments are connected through the themes of social justice, universal design, and early field experiences for these pre-service teachers. Faculty that teach these courses participate in professional development to support their course connections and learning across content areas such as sociology and environmental science. Such a program is an example of how common themes, like environmental and climate change literacy, can integrate across pre-service teacher undergraduate courses.

ORGANIZATIONS DOING MEANINGFUL WORK IN ENVIRONMENTAL EDUCATION FOCUSING ON PRE-SERVICE TEACHER PREPARATION

These organizations have a capacity for expanded integration with California postsecondary and teacher education. A few such organizations include:

- **North American Association for Environmental Education (NAAEE)**

  NAAEE is a professional development and educational organization which serves as a champion and backbone for the field of environmental education, working with a diverse group of educators in the United States, Canada, and Mexico to advance environmental education on the ground (Appendix 2.2). The three pillars of their work include: 1) driving excellence by promoting professional development and best practices in environmental education; 2) cultivating collective impact by bringing people together to create change; and 3) mobilizing support by championing environmental education at all levels. NAAEE had developed *Guidelines for Excellence: K-12 Education*. These guidelines are aligned with the Common Core and Next Generation Science Standards and provide content, activities and rubrics for each grade level.

- **K–12 Linked Learning Best Practices/ Green Pathway Schools**

  In California, an innovative K–12 approach called "Linked Learning" (Appendix 2.2) is addressing the question of how to support teachers in becoming effective environmental educators and integrating environmental and climate change literacy into their teaching. Specifically, the approach has sought to integrate green pathways that include environmental themes into a problem-based learning approach. Green pathways emphasize courses based on environmental industry sector themes, such as Agriculture, Engineering & Design, Energy & Utilities, and Transportation. The green pathways encourage teachers to incorporate relevant environmental and climate change literacy information into the standard A-G curriculum.

  ▶The Charter College of Education at CSU Los Angeles is currently conducting a research project addressing what the best practices for these green pathways teachers are (Appendix 2.2). The researchers aimed to identify the aspects causing difficulties and help teachers move towards specific objectives. The following emerged as key best practices for teachers in environmental and climate change literacy:

  Social context analysis—understand the community of students being taught and show them how environmental studies are relevant to their lives

  Use a systems approach—include all stakeholders within that community: students, teachers, parents, school administrative staff, school district, and industry experts

  Use technology to establish a platform for value creation (via a mobile app and/or website designed specifically for the environmental and climate change literacy pathway). The CSU team did this by designing an app they named "mobile community of practice" (m-CoP). This m-CoP app allows teachers to post assignments, students to post projects, and all to share relevant information regarding environmental education and literacy.

- **Bioneers**

  Bioneers is an innovative nonprofit organization that highlights breakthrough solutions for restoring people and planet (Appendix 2.2). It was founded in 1990 and serves as a hub for social and scientific innovators with practical and visionary solutions for the world's most pressing environmental and social challenges.

- **California Education and the Environment Initiative (EEI)**

  The goal of this state law, known as EEI, was to help students better understand their relationship with the environment. After developing the Environmental Principles and Concepts (EP&Cs) (2004), the State of California created a K–12 model curriculum (2010) that demonstrated the incorporation of the EP&Cs into standards-based instruction in science and history-social science.

It is important to note that as of 2016, these EP&Cs are embedded within the California frameworks for the new standards for Science, History-Social Science and Health (2019).

- **Bending the Curve: Climate Change Solutions**

  A multifaceted education project initiated by the University of California (UC) with participation by all ten campuses of the UC system, this educational program is centered on a curriculum designed to empower a million climate champions across the world to solve the climate change problem. The program was inspired by the report *Bending the Curve: 10 Scalable Solutions* which was written by 50 UC academics in natural sciences, engineering and technology, social sciences, and humanities. The project began with a single for-credit hybrid undergraduate course taught at UC. To scale it to the rest of the nation and the world, it has expanded in scope to include an online version of the course, an open-source digital textbook available for download through the California Digital Library, and a massive open online course (MOOC). The education project provides students with the tools to develop climate change solutions in different disciplines, including science pathways, societal transformation, governance, market instruments, technology measures, and ecosystem management.

- **Science Education Resource Center (SERC)**

  SERC (Appendix 2.2) hosts curated sets of earth and environmental science curricular material that can be geared toward pre-service teacher courses taught at the university level:

  InTeGrate (Interdisciplinary Teaching about Earth for a Sustainable Future) materials "engage students in understanding the earth system as it intertwines with key societal issues (Appendix 2.2). They challenge students to address interdisciplinary problems, engage in geoscientific habits of mind, work with authentic geoscience data and develop systems thinking. The collection is freely available and ready to be adapted by undergraduate educators across a range of courses including general education or majors' courses in Earth-focused disciplines such as geoscience or environmental science, social science, engineering, and other sciences, as well as courses for interdisciplinary programs." There are several modules designed specifically for use in pre-service teacher courses and discussions of connections with the California Next Generation Science Standards (CA NGSS).

  Earth Labs provides a national model for rigorous, engaging Earth and environmental lab science courses. These units illustrate a sequence for learning science concepts through data analysis, activities, satellite imagery, computer visualizations, and hands-on experiments that illustrate processes of our Earth System.

- **Climate Literacy and Education Network (CLEAN)**

  This network hosts a high-quality and rigorously reviewed collection of climate and energy educational resources aligned with the Climate Literacy and the Energy Literacy frameworks, and the Next Generation Science Standards. Through the peer-review process scientists and educators ensure scientific accuracy, pedagogic effectiveness, and classroom readiness for each resource. Lessons and activities can be searched for different grade levels, including at the university level. (Appendix 2.2)

Challenges

Many of the challenges the committee identified for embedding environmental and climate change literacy into pre-service courses at the university parallel our recommendations. Environmental and climate change literacy is highly multidisciplinary and therefore needs across-college conversations and integration. Pre-service teachers take content courses within the subject departments and these prepare them for their education courses that are offered through colleges or schools of Education. Most pre-service teachers tend to teach the content subjects as they were taught, so it is imperative that we **model the teaching of environmental and climate change literacy in our content departments**.

An initial set of challenges includes:

- How do we hold faculty accountable for this?
- The pressure of Rank, Tenure, and Promotion (RTP) already burden many young faculty. Do we add this as a teaching strand for review under RTP, and how do we offer support for appropriate integration of environmental topics? Could we integrate through service-learning projects or citizen-scientist projects?

The next set of challenges is within the pre-credentialing education courses. Methods courses also need to model environmental and climate change literacy. When it comes to fieldwork, we must recognize that many of the master teachers who the student teachers are matched with, have not been trained in environmental and climate change literacy themselves. If we could prepare new pre-service candidates to teach environmental and climate change literacy, then their master teachers could benefit from being open to learning from their student teachers. Again, we have the challenge of accountability. For example, how does this look for the credentialing standards? Should this be added to the state credentialing process? Embedded within this is also the support of administrators at all levels. We must educate administrators at the PK–12 school sites where pre-service teachers are student teaching to help support the integration of environmental and climate change literacy. Moreover, of course, we need the support of university administrators for both the CSU and UC systems.

Bringing the Work to Scale

To bring this work to scale we need a systems approach that includes educators (teachers and administrators), students, parents, and all community members (Board of Trustees, School Board, unions, universities, nonprofit organizations, and accrediting bodies such as the Commission on Teacher Credentialing). This must be a 21st Century model of education that recognizes the need to incorporate media, information, and technology, along with all forms of communication into a process of understanding of environmental and climate change literacy in the digital age. In the same way the Common Core State Standards require literacy and quantitative reasoning to be taught in all subject matter areas, environmental and climate change literacy should be integrated across all relevant content.

We need to build partnerships internationally, nationally, and at the state level with the county offices of education. These partnerships should bring expertise from the community into the schools and classrooms (to support teachers with lessons), while also taking students out into the community for place-based learning with real-world experiences and actions. Working together with multiple partners would provide resources from the state blueprint in STEM, environmental, and civic literacies. These networks should strategically assist highly impacted communities of color with opportunities to have a voice in addressing local environmental issues (rural and urban).

Environmental and climate change literacy involves competencies, practices, concepts, attitudes, and values. This involves the entire body: learning information and awareness about our current climate crisis and other environmental issues (the head), developing the disposition and attitudes of empathy, empowerment, and stewardship with and for the environment (the heart), and applying the skills and abilities to analyze critically and take actions (the hands). **Environmental and climate change literacy is intimately connected to social justice because human life is interdependent with nature, and environmental changes do not affect everyone equally.** Since environmental crises have typically impacted the poor and people of color disproportionately worse than wealthy people and nations, environmental and climate change literacy poses human rights issues, social justice concerns, and questions about who is more affected by environmental problems and who is most responsible. Integrating environmental and climate change literacy across content areas provides an opportunity for students, especially those who have been marginalized, to become stakeholders in solving local and global environmental challenges.

Teacher education programs need to play a strong role in preparing new teachers to teach environmental and climate change literacy and in the future serve as a resource to support collaborative efforts with other teachers. It is not enough to relegate this to a single methods course or an optional project. These ideas should be integrated into foundational theory courses as well as multiple methods classes and projects and into content courses that these students take in other departments. All student teaching placements should require an environmental and climate change literacy lesson or unit with support from the master teacher and/or teacher education program.

IN-SERVICE

The in-service chapter of this report serves to suggest recommendations to the field, existing best practices and resources for educators, and ways of bringing the work to scale for teachers who are and will be teaching environmental and climate change literacy to PK–12 students in California. This chapter will address some ways that teachers can be supported through professional learning opportunities, classroom and curricula setup and practices, and more.

It is important to note that the push for increased environmental and climate change literacy comes not only from the stakeholders already involved in environmental and climate change literacy projects, but from the teachers and students in PK–12 classrooms across California, who want to understand and address imminent and pertinent issues on environmental and social justice. Pushing for environmental and climate change literacy does not only serve to increase academic knowledge; it also gives communities the information and tools necessary to begin to address socio-environmental issues that are happening around them in real time.

Challenges to Key Recommendations

Current challenges to achieving environmental and climate change literacy through PK–12 education can be largely sorted into structural issues inside the education system itself, and outside the system, in relation to communities and other organizations and institutions. Looking at the current state education system, funding for environmental and climate change literacy is insufficient, and more resources and support need to be given to teachers in order to increase their confidence and ability to empower their students to address environmental issues and climate change in today's classroom.

Teachers experience a lack of administrative support for outdoor teaching and learning and environmental and climate change literacy projects and programs; a lack of administrative support or resources for bringing in guest speakers and experts to engage students in learning about these topics; and a lack of professional learning opportunities and interdisciplinary teaching resources that garner administrative support. To address these challenges, it is necessary to make environmental science and climate change literacy a priority, so that all students receive a solid foundation in understanding both scientific issues and the nature and socio-historical context of science, and become better prepared to understand and act on environmental issues and climate change in holistic, interdisciplinary, and action-oriented ways. Administrative support will help allocate necessary time and resources towards environmental and climate change literacy and create an environment conducive to holistic, interdisciplinary learning around environmental issues and climate change that benefits individual students and families, the local community, statewide and national efforts, and the world.

Outside the education system, environmental and climate change literacy, especially related to environmental justice, is inherently tied to the communities being served by schools. Challenges here arise when teachers have a disconnect with the communities that they serve and are thus unable to address the specific environmental issues that are pertinent or relevant to the students and their families, or when schools are located in communities that have negative perceptions related to environmental issues and/or the idea of climate change.

In both cases, it is necessary for teachers, as well as their schools as a whole, to better understand their surrounding communities, meet them where they are in terms of environmental and climate change literacy, and teach in a way that is accessible, approachable, and appropriate for the given context of the community. Rather than applying a blanket approach to curriculum, teachers should be given the resources and support to build environmental and climate change literacy in the way that is most effective for their context.

Key Messages in Recommendations

With multiple challenges in mind, there are several key points to communicate moving forward.

Funding is an integral issue and without a dedicated source of funding, it is impossible to create a system that can effectively and structurally support educators in teaching environmental and climate change literacy. Even with existing programs and strategies, additional funding is necessary to scale up and make these programs and strategies be better known, have necessary supports, and be more widely used.

Making changes in resources and policies comes hand in hand with funding. To help strengthen science education and ensure environmental and climate change literacy, in 2016 the Lawrence Hall of Science at UC Berkeley created an LCAP Toolkit (Appendix 3.3) to help teachers, administrators, and other stakeholders advocate for science and environmental education during their local school districts' budget development processes. One method of securing funding for environmental and climate change literacy is ensuring that it is included as a priority item in the LCAPs of local educational agencies (LEAs), thus designating resources for environmental and climate change literacy curricula and projects for students.

There are available curriculum resources, such as the California Education and the Environment Initiative (EEI) science and history-social science units that can be updated and promoted to support learning around environmental and climate change issues. To better understand the current impact of these resources, stakeholders should be informed of the current number and locations of teachers who make use of the EEI curricula and other sources, and ways of expanding this impact should be implemented. To scale up the use of existing resources intensively and extensively to address access and equity issues, funding will also be necessary.

Learning Frameworks and Best Practices

Learning frameworks and practices that teachers can adopt to facilitate learning about environmental and climate change topics should focus on being interdisciplinary, holistic, and connecting different geographical and theoretical contexts. They should also involve active, experiential, place-based learning strategies and help students to start thinking from community needs and wants, rather than imposing decontextualized blanket solutions.

Some examples of such learning frameworks and practices to implement in the classroom include design thinking, project-based learning, and phenomena-driven three-dimensional learning via the California Next Generation Science Standards (CA NGSS) and Universal Design for Learning.[13] These practices can be implemented while engaging students in experiential learning outside the classroom to explore natural and human-built environments and systems as near as on-campus and as far as field studies will allow. Students should be encouraged to be active citizens by learning about civic engagement and being exposed to individuals, agencies, and professionals already doing work in communities and learn to think in both local and global contexts by learning and developing geographic reasoning and spatial thinking.

Besides classroom practices, educators can also engage in receiving academic content or subject support by working in cadre models, where institutes of higher education—such as UC–CSUs—provide educational resources for teachers to work with and provide to their students. Educators should also strive to work together locally through action research, lesson study, and professional learning communities, where they can come together to create action plans, design lessons, assess lesson effectiveness, and discuss student work. The California Subject Matter Project, as well as other professional learning providers, undertake much of this work connecting PK–12 educators with university scholars. The California Science Project, California History-Social Science Project, and California Global Education Project in particular have developed professional learning programs to connect local expertise and scholarship in environmental and climate change literacy with PK–12 educators.

Bringing the Work to Scale

The messaging around environmental issues and climate change, as well as their various impacts on different communities, makes it difficult and inadvisable to offer a blanket approach or one-size-fits-all solution to addressing environmental and climate change literacy. Rather, it will be necessary to consider equity, access, cultural relevance, and units of change—or levers—within the education system, which will help all educators better understand how to best introduce environmental and climate change literacy. Recommendations for such an approach follow a set of policies and principles that should be kept in mind while scaling the work, as well as concrete, specific ways that these policies and principles can be actualized.

BROAD POLICIES AND PRINCIPLES

When approaching the work of increasing environmental and climate change literacy, include the following:

- **Create shared vision, curriculum guidelines, and learning goals**

  Consider how environmental and climate change literacy and disciplinary standards overlap to create a shared vision, curriculum guidelines, and learning goals. Rather than having environmental and climate change literacy education be housed and taught within science education only, all disciplines and curriculum guidelines should be considered in full and undergo a norming session that ensures that environmental issues and other areas of education are taught with an interdisciplinary approach, with connections drawn between various areas of study, so that students better understand multidimensional, large-scale issues like climate change. The Science, History-Social Science, and Health frameworks, presenting the integration of environmental principles and concepts, are a good starting place for this work within and across these disciplines.

- **Design professional learning systems to adhere to the Quality Professional Learning Standards**

  In developing and providing effective professional learning programs, providers should use California's statewide standards for effective professional learning as presented in the California Department of Education's document *Greatness by Design*. Evaluations and feedback should be used to ensure that professional learning impacts teacher practice and is aligned with the goals and principles of environmental and climate change literacy education.

- **Provide professional learning opportunities**

  Provide ongoing, collegial, meaningful opportunities for educator learning, classroom implementation, and alignment of instructional materials. Professional learning opportunities should be comprehensive and offer a variety of options that come together to address all components of what in-service educators need to provide environmental and climate change instruction for PK–12 students.

- **Engage partners and key stakeholders to support implementation of environmental and climate change literacy initiatives**

  Any and all stakeholders in positions of authority that could be beneficial to implementing environmental and climate change literacy initiatives should be engaged, as they can provide the necessary support and resources for environmental education, especially in areas where environmental issues or climate change are controversial topics.

- **Align large-scale educational policies to support implementation of environmental and climate change literacy initiatives**

  Having large-scale policies support environmental and climate change literacy will ensure a uniform, principled approach across the state.

- **Build administrative support at all levels, with a particular focus on principals**

  Administrative support plays a vital role in building sustainable environmental and climate change literacy programs. Approaching principals specifically can ensure that messaging and support for environmental education is spread throughout the entire school community, rather than classroom by classroom.

- **Connect various programs on environmental and climate change literacy by bringing leadership together**

  Along with norming principles and goals on environmental and climate change literacy and interdisciplinary learning, existing programs can come together to pool their resources and create a united front on environmental and climate change literacy goals and recommendations.

- **Engage innovators in education**

  As educators and schools embrace innovation in education, ensure environmental and climate change literacy is included in efforts to better engage students in real-world problem solving, global competence and collaboration, curiosity and creativity, and inquiry learning.

SPECIFIC METHODS OF SCALING THE WORK

These methods parallel many of the recommendations made earlier in the report and are included here in short form.

Building environmental and climate change literacy, with the aforementioned principles in mind, includes the following:

- Include shared vision and learning goals of environmental and climate change literacy in educator evaluation and professional learning expectations.
- Allocate dedicated funding to explicitly support implementation of environmental and climate change literacy initiatives and education around climate change.
- Include specific, targeted funding allocations for environmental and climate change literacy work in Local Control and Accountability Plans (LCAPs).
- Coordinate policies and teaching practices with existing statewide networks.
- Push for policies that include and address environmental and climate change education within local government plans, such as climate change plans.
- Loop in PK–12 educators and involve them in local planning work.
- Create statewide communication and advertising campaign to raise public awareness and highlight environmental and climate change literacy as an integral part of a good education.
- Build green facilities that match green curriculum using the Green Ribbon Schools Program, so students can see and experience environmental sustainability and climate change adaptation created from the ground up.

CURRICULUM

Climate change is an inherently inter- and trans-disciplinary crisis that spans all academic disciplines and defies singular solutions. Fortunately, systems thinking is a powerful way to make sense of this global problem. Since 1990, the United Nations Framework Convention on Climate Change[14] (UNFCCC) treaty has recognized education is a lever of change and that empowering educators and students as critical messengers of climate and energy literacy is a key part of the solution to climate change. Over the last two decades, California's legislature and various state agencies have evolved a supportive context to help prepare educators and students in the PK–12 system to identify and contribute to solving environmental problems in their local communities—by developing an enduring understanding of interdependent human and natural systems in a standards-based context.

With the widespread adoption of the Next Generation Science Standards, including in California (2013), climate change-aligned curricula and supplemental resources already exist at the local, state, and national levels—but much work remains in preparing future and current teachers to confidently teach the topic. Beyond science, we also need a concerted effort to bring educators in PK–12 and higher education together to mobilize the insights of history-social science, health, public policy, media studies, and arts practitioners. Implementing this vision of true environmental and climate change literacy and graduating the inspired and empowered young adults we need for a sustainable future will require strategic collaboration among influential institutions such as our schools and departments of education in the UC and CSU systems and our system of support in PK–12 via county offices of education, school districts, and schools. Community-based organizations and other partners such as professional learning providers also have a critical role to play in advancing this work.

Current Best Practices and Resources

The UC and CSU systems need not focus on the creation of new curriculum but rather on the effective adaptation and localization of available curriculum to California classrooms. Fortunately, the UC and CSU systems can draw upon a rich body of state, national, and international curricular resources to bring environmental and climate change literacy to scale in California for future and current teachers. They are also in a unique position to localize existing resources so they become even more relevant to teachers and students based on the communities where they teach and live. This section includes five best practice recommendations for delivering environmental and climate change literacy curricula and supplemental resources, and includes a series of vignettes illustrating this type of work in action in classrooms across the state.

BEST PRACTICES IN THE NATIONAL CONTEXT

The Clean Energy Awareness Network (CLEAN) is funded by grants from the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation, and the Department of Energy; it is the preeminent national source for environmental and climate change literacy information and resources. Authored by NOAA and the American Association for the Advancement of Science, *Climate Literacy: The Essential Principles of Climate Science,*[15] is an interagency guide that provides a framework for formal and informal education about climate change. To implement these principles in PK–12 instruction, CLEAN curates an extensive portal,[16] which contains a collection of authoritative and rigorously peer-reviewed digital climate and energy education resources. These tools provide links between educators and scientists that are especially valuable in a quickly evolving field of study.

BEST PRACTICES IN THE CALIFORNIA CONTEXT

California's educational context lends itself to a set of interrelated best practices for teaching about climate change and solutions. California's curriculum standards and frameworks explicitly define climate and environment-related content knowledge, skills, and enduring understandings students are expected to acquire as well as instructional approaches best suited to help them achieve these goals. These enduring understandings about the interdependence of natural systems and human social systems are expressed through California's Environmental Principles and Concepts (EP&Cs). The EP&Cs are currently integrated into three curriculum frameworks in California: Science (2016), History-Social Science (2016), and Health (2019).

In the discipline of science, climate change is explicitly and implicitly addressed in Next Generation Science Standards throughout the grades, as outlined in NOAA's publication, *How Learning About Climate Change Progresses in Next Generation Science Standards (K–12).* California adopted the Next Generation Science Standards in 2013, and in 2018, the State Board of Education released a list of approved adopted science curricula for grades K–8.[17] California is a large state with over 6.2 million public school students and over 300,000 teachers. The California NGSS Collaborative, which includes the California Department of Education, California Science Project, California Science Teachers Association, California County Superintendents Educational Services Association, and the K–12 Alliance at WestEd, has been working hard since the adoption of the NGSS to reach as many teachers as possible. Despite sold out events across the state over the last five years, there is still much work to be done to reach all teachers of science and other venues where climate change could be taught.

The California Next Generation Science Standards Collaborative has now trained science leaders in every region to use the Toolkit for Instructional Materials Evaluation (TIME).[18] TIME is both a toolkit and embedded professional learning that includes rubrics for the evaluation of instructional materials through a paper screening process and pilot of instruction materials that are recommended at the end of the paper screening process. Three criteria included on the screening rubric for selecting instructional materials that relate to this work are: 1) the extent to which materials provide content that incorporates California's EP&Cs; 2) opportunities for students to examine the interactions and dependence of human societies and natural systems; and 3) opportunities for students to develop and/or implement solutions to real-world environmental problems.

For educators who choose to make climate change a priority, the infrastructure is in place to engage colleagues in serious dialogue around choosing the highest quality teacher and student materials provided in each published curricular and supplemental resource. One downside of the integration of the EP&Cs with CA NGSS's three dimensions is that teachers are struggling to identify where and how the EP&Cs are being addressed or assessed. This may be remedied by requesting or requiring that publishers provide a crosswalk to help them locate EP&Cs in general or climate change content, specifically.

Beyond science, the humanities also provide PK–12 students invaluable tools for critical inquiry and building solidarity to transform the ethics that have thus far normalized unsustainable and inequitable ideologies and practices. There is consensus within the scientific community about the occurrence of climate change and drivers for climate change, both natural and anthropogenic. There are, however, substantial political, socio-economic, cultural, and psychological obstacles to enacting individual and collective behaviors that will bend the curve on our emissions. Fortunately, California's Senate Bill 720 (Allen, 2018) amends Education Code Section 51227.3 to require that the EP&Cs be "integrated into the content standards and curriculum frameworks in the subjects of English language arts (ELA), science, history-social science, health, and, to the extent practicable, mathematics whenever those standards and frameworks are revised."[19]

The recently revised History-Social Science Framework (2016)[20] explicitly and consistently identifies climate change as an important topic of study. For example, a topic for 10th-grade world history students to explore is that "Climate effects traceable in part to the environmental consequences of reliance on fossil fuels are leading to demands for changes in the way energy is produced and used. Meanwhile, climate change has contributed to political and economic upheavals that are changing patterns of human migration and fueling regional conflicts" (p. 375). In Appendix D of the History-Social Science Framework, "Teaching the Contemporary World" states that "nations face challenges and threats that transcend their borders. They include environmental degradation and global climate change" (p. 757). Appendix B of the History-Social Science Framework also discusses the broad theme of Science, Technology, and the Environment with applications to multiple grade levels.

As California's English Language Arts and Mathematics frameworks are revised to catch up with environmental content already integrated into the adopted Science, History-Social Science, and Health frameworks, educators across the board will be well positioned to tackle climate change head-on in any school setting. To do so, educators may look to the book[21] and accompanying website[22] *Teaching Climate Change to Adolescents: Reading, Writing, and Making a Difference*, published by the National Council of Teachers of English. They describe numerous classroom-tested approaches to addressing climate change through "cli-fi" literature, media studies, gaming, drama, and interdisciplinary curricula. Climate Generation has recently published humanities curriculum guides to augment its STEM offerings. Because the majority of states have adopted the Common Core State Standards for English Language Arts (42 states) and Mathematics (41 states), climate-related curriculum can be shared nationally.

BEST PRACTICES IN THE DEVELOPMENT OR MODIFICATION OF CURRICULUM

Based on the above foundations, we recommend the following five best practices to be considered in the development or modification of any curriculum for teaching California's future and current teachers and students about climate change. Following the list is a series of vignettes that exemplify one or more of these practices in action in public schools across the state.

Best Practice 1: Curricula should teach climate change as expressed in the California Next Generation Science Standards (CA NGSS) and the California Science Framework with explicit connections to California's EP&Cs.

Best Practice 2: Curricula should teach climate change via connections to California's EP&Cs and as outlined in California's adopted frameworks in History-Social Science and Health.

Best Practice 3: Curricula should guide teachers and students to explore real-world phenomena through outdoor and environmental place-based experiences, participate in problem-based learning and apply engineering design strategies to solve real-world problems.

Best Practice 4: To engage and empower students, curricula should activate students to play a significant role in culturally relevant community issues in an integrated, interdisciplinary, and developmentally appropriate way.

Best Practice 5: The teaching of climate change needs to be coherent and coordinated across school and community experiences.

VIGNETTES OF BEST PRACTICES

VIGNETTE 1

Designing Solutions for California's Energy Future in the Central Valley

In 2018, a suite of PK–12 learning sequences was developed by members of the California Science Teachers Association (CSTA) in collaboration with practicing climate scientists.[23] The teachers that developed them piloted these lessons in classrooms. In addition, they underwent peer review and the Next Generation Science Standards Lesson Screener was utilized to revise and update them.[24]

In a high school physics unit, "Considering California's Energy Future,"[25] students discuss and read about the prevalent phenomena of poor air quality in their own backyard. Then students identify what they would like to know more about to determine both the causes of air pollution in the Central Valley and solutions to the problem. Students are given the opportunity to find patterns in the data they propose and explore connections between both natural and human-made events that might be causing the poor air quality. Once students determine clear causes of the Central Valley air pollution, they explore solutions to control the air quality and reduce the impacts of humans on the environment, including choices individuals, communities, and governments can make. Students use Governor Brown's executive order on carbon neutrality and SB 100 (converting California to 100% renewable energy for electricity by 2045) as a framework for designing their solutions and present these proposals to the class for their final assessment.

This teacher- and researcher-created curriculum illustrates three related best practices. This unit addresses science and social studies standards by having students examine data and public policy documents in the context of a pressing environmental justice and community health issue (Best Practices 1 and 2, respectively). Specifically, this unit addresses the NGSS Disciplinary Core Ideas that "all forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits and new technologies and social regulations can change the balance of these factors" (ESS3-A) and "when evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts" (ETS1-B). More than just an engaging phenomenon, air quality is a highly relevant climate change-related health danger that today's youth around the world are bringing a sense of urgency to their teachers, mentors, and employers in policy, industry, and science to solve together (Best Practice 3). This learning sequence directly addresses California's Environmental Principles and Concepts (EP&C) Principle IV, Concept C, which states that students should understand that "the capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts." Cutting-edge curriculum such as this raises awareness and prepares students meaningfully for green college and career pathways crucial to our collective quality of life.

VIGNETTE 2

Career Development through Student Leadership Projects in Marin County

The Marin School of Environmental Leadership (MarinSEL) at Terra Linda High School, a project-based, environmentally focused, "school within a school" that emphasizes development in leadership and 21st Century skills, designed and supported by Strategic Energy Innovations (SEI),[26] is a model for transforming public education. Students dedicate four years to becoming environmental leaders and follow an Entrepreneurship Career Technical Education (CTE) pathway. They take NGSS-aligned coursework ranging from ocean acidification and energy auditing to sustainable enterprises and environmental engineering. Multiple A-G subject courses have been integrated with both environmental and leadership skill development, including English, History-Social Science, Health, and Science courses. Students are active in community projects with significant climate protection impacts during their freshman and sophomore years. In the past nine years, students have led local resilient neighborhood initiatives, reduced waste by eliminating single use plastic, and successfully petitioned for their local school district to move to 100% renewable electricity with local utilities. They created iMatter Climate Report Cards for the city and county, which resulted in a citywide youth ordinance and the entire City of San Rafael committing to 100% renewable electricity. Students intern with a local organization their senior year of high school to lead a sustainability project with organizations such as the San Rafael Airport, MCE Clean Energy, Clough Construction, Marin County Office of Education, and Zero Waste Marin.

Strategic Energy Innovation's A-G Career and Technical Education (CTE) approved courses provide a solid foundation from which a school can help young adults expand their efforts into the community. The curriculum for courses such as "Innovations in Green Tech," "Energy and Environmental Design," and the "Solar Certificate" is free to California educators. They help students explore in a robust manner how to apply engineering solutions (Best Practice 4) in their own community as they transition through high school to vocational training and higher education (Best Practice 5).

VIGNETTE 3

Student Engagement through a Youth Climate Summit in Cupertino

Chemistry teacher and 2019 National Geographic Educator of the Year Kavita Gupta from Monta Vista High School hosts an annual Youth Climate Summit that unifies students, staff, and local experts around a common cause. As a teacher-leader, she brings her colleagues together from different departments for monthly planning sessions in which teachers are encouraged to address climate change where it naturally fits in their curriculum in ways that help students meet multiple standards at once. The summit itself is a presentation of learning where students share out the results of their climate-related research. Ms. Gupta's chemistry students presented their findings in a four- to five-page paper and in poster sessions. In other 9th–12th grade classes such as journalism, ceramics, drama, and English, students demonstrated and deepened their content knowledge and expressive communication skills by performing songs, creating interactive booths, displaying artwork, and presenting short stories and websites. On the day of the summit, held at the San Jose Tech Museum, scientists and policy makers provided feedback on student presentations. Ms. Gupta reflected on the event: "High schoolers feel small with big problems. They think, 'I don't matter.' I have seen what it gives kids—that confidence, and the real meaning of education. When the experts look at your work, it validates you. Many students pledged to walk to school two days a week, to do real impactful things. They used modeling and data visualization and saw how other people benefitted from their small actions. They realized 'Yes I have a voice and a choice.'"

While standards-aligned instructional materials and district-wide adoptions of high quality published curricula are crucial assets in climate change education, the generative power of local creativity and flexibility cannot be overrated—nor can the influence of student voices be ignored. The Youth Climate Summit approach models the process of national and international collaboration and can spur schools and community members to informed action (Best Practices 4 and 5). Ms. Gupta has created an Educator Guide[27] to help with the process and the National Science Teaching Association (NSTA) has published a flexible and user-friendly guide[28] that incorporates a similar research process and youth summit.

Challenges

A Charged Topic

Even though teaching climate change is supported in California, it poses unique challenges to teachers because of the mixed and politicized messages in the broader culture. Despite decades of international collaboration, the United States is not a party to the Kyoto Protocol (1992) and intends to withdraw from the Paris Agreement (2015) after the 2020 election. **The most important myth to debunk is that there is not scientific consensus about the phenomena of climate change and its human causes.**[29] In addition to the political scene, climate change is an emotionally charged topic, and there is often a lack of clear guidance about the appropriate way to broach the issue with children of different ages. Thus, climate change can slip through the cracks for overloaded educators in favor of more palatable and less fraught issues. Fortunately, as a result of California's standards, frameworks, and *Blueprint for Environmental Literacy*, work is under way to cultivate a more inclusive movement for environmental and intergenerational justice, which will illuminate climate change as the shared existential crisis, and humanitarian opportunity it truly is.

Teachers Need Content Knowledge in Climate Science

Gaps in teacher content knowledge create a challenge that extends beyond curriculum to undergraduate and pre-service programming, as noted in those sections of this report. There is currently no guarantee that undergraduate coursework for future teachers (even in California's public universities) includes climate change content. Large-scale education reform movements have affected the amount of science taught and the level of investment in professional development for science teachers, leaving many teachers lacking up-to-date content knowledge regarding climate change. The *No Child Left Behind Act* (2001) is known to have narrowed curriculum and instructional time to the most heavily tested subjects of math and English.[30,31,32] More recently, the 2010 adoption of the Common Core State Standards (CCSS) and their assessments (the Smarter Balanced assessments in California) in those two subjects have required substantial, multi-year learning arcs for teachers and administrators. Although California's science standards (1998) were replaced with the California Next Generation Science Standards in 2013, implementation across such a large state takes time. This work continues to scale as professional learning rollouts, currently in year six, continue to be offered throughout the state in a "train the trainers" model by county offices of education.

Shifts in the CA NGSS and California Science Test (CAST) are currently impacting course content and sequences in ways that call for many teachers to learn new content knowledge. According to the California Science Teachers Association (CSTA), "For elementary teachers, who tend to have more preparation in ELA and math than in science, professional learning needs to help deepen science content knowledge."[33] In middle schools, departments are currently grappling with whether to maintain a discipline-specific course model or move to the state's recommended integrated model. In high schools, teachers are grappling with their master schedules, considering the two years of lab science required for UC and CSU admissions and the four-year sequence that would include in-depth studies of biology, chemistry, physics, and often neglected earth systems science. Teachers are being asked to learn additional science content knowledge outside of their degrees and comfort areas. Climate and Earth systems science was not generally a required part of high school, undergraduate, or graduate education of current classroom teachers.

Publishers and the California State Board of Education very recently (2018) approved instructional materials aligned with the rigors of the three dimensions of CA NGSS and California's EP&Cs simply because it takes time to create, pilot, and finalize instructional materials. Science achievement in each grade band will be added to the California School Accountability Dashboard system in the coming years, so by all accounts, now is the time many districts are devoting resources to science professional development and curriculum adoption efforts. This timeline provides a crucial opportunity to make climate science an important priority for teachers and students.

The Need for Interdisciplinary Systems Thinking

It is also clear that solving our climate challenges will require a multi-disciplinary, systems thinking approach that incorporates the physical and social sciences. Students need to do more than evaluate scientific data; they also need, for example, to study the history and legacies of the Industrial Revolution (a prominent topic in our History-Social Science framework and standards), interrogate political and economic systems, and draw upon sophisticated communication and collaboration skills. Research has shown that "understanding ecosystem relationships as scientists do involves reasoning about forms of cause and effect that most students are unfamiliar with. Students typically reason using simple linear cause and effect…They tend to miss the connectedness within systems."[34] Understanding climate change requires conceptual understanding of domino, cyclic, and two-way causality, indirect effects, time delays, non-obvious causes, and reasoning about populations. Science teachers often feel uncertain about their ability to teach across disciplines, and teachers from other content areas often feel intimidated by the science. Professional learning around environmental and climate change literacy is often thought of as most appropriate in science.

We must mobilize buy-in and support for the inclusion of climate content in trainings, seminars, workshops, and conferences in each of the disciplines, as well as in cross-disciplinary collaborations. Collaboration time even within departments is rare in most California schools, let alone training and support for interdisciplinary curriculum mapping and unit planning or the relationship and knowledge building that are needed to support it.[35] Given this context, it is no wonder teachers generally feel uncertain about how best to approach

environmental and climate literacy in their classrooms, departments, and schools.

Localizing The Curriculum

Teachers need help localizing curriculum to engage students in culturally relevant, place-based inquiries and support in helping students design solutions that often involve taking informed actions. Published curriculum will help teachers understand science content, but it will not necessarily address specific climate change related issues different communities face.

The sheer geographic and demographic diversity across California necessitates a number of approaches to be developed simultaneously. In addition to expertise in localizing units of study by investigating local phenomena, teachers will need support in enacting action-oriented pedagogy.

As distinct from community service, environmental service learning is a form of civic action, which integrates academic content and interaction between youth and adults to improve a community. Many teachers may fear that getting political threatens their job security. There is another set of educators who consider it their moral responsibility to engage students with current events but require training in action-oriented pedagogies and logistical support in facilitating meaningful out of the classroom learning experiences for students.[36] Future research based off the *Science Instructional Practices Survey*[37] will help leaders better understand the needs of California's teachers. When it comes to climate change, there is a growing sense that environmental and climate change literacy for students entails both an understanding of complex systems and the empowerment of lived experience in influencing these systems for the better through individual and collective endeavors.

Bringing the Work to Scale

To bring these recommendations to scale, the UC and CSU systems will need to secure investments in funding and coordination. Dedicated staff across the systems and personnel to support faculty at each university are essential for the broad piloting, implementation, and accountability for enacting substantive changes in PK–12 schools. Partnering with local community-based organizations and campus institutes will help support educators who may be facing a range of technical and political obstacles at their sites.

To scale further, the UC and CSU systems should connect to other networks doing similar work and partner with initiatives well underway such as the California Environmental Literacy Initiative, led by NGO Ten Strands and focused on implementing California's *Blueprint for Environmental Literacy*. California will be positioned well to share works with other leading climate action states across the nation and learn from them on these practices and strategies. For example, through Washington State's ClimeTime initiative,[38] the University of Washington uses state budget funding to coordinate teacher professional development and helps sub-grantees to develop instructional materials, design related assessment tasks and evaluation strategies, and facilitate student events.

APPENDICES AND RESOURCES

APPENDIX 1.1

Foundational California Initiatives

Education and the Environment Initiative

Assembly Bill 1548 (Pavley, 2003) launched the Education and the Environment Initiative by mandating the creation of a multi-agency partnership to develop California's Environmental Principles and Concepts (EP&Cs) and develop a model curriculum that demonstrates how to integrate the EP&Cs into standards-based instruction for all K–12 students. The State Board of Education approved the EP&Cs in 2004.

Blueprint for Environmental Literacy

In 2014, former State Superintendent of Public Instruction, Tom Torlakson, launched a taskforce to write a Blueprint for Environmental Literacy. The Blueprint, published in 2015, is a call to action for the education community to educate every California student in, about, and for the environment. The guiding principles for taking this work to scale are equity of access, sustainability and scalability of systems, collaborative solutions, commitment to quality, cultural relevance and competence, and exposing students to a variety of learning experiences in classrooms and outdoor environmental settings.

In 2016, Torlakson formed a steering committee, which is now operating as the California Environmental Literacy Initiative (CAELI) and leading the work in PK–12 by advocating for a supportive state context, supporting the incremental infusion of environmental literacy into the PK–12 instruction, professional learning, assessment, and accountability infrastructure, and cultivating leading-edge district and county office of education exemplars.

California Regional Environmental Education Community (CREEC) Network

The California Regional Environmental Education Community (CREEC) Network fosters regional partnerships throughout the State of California to promote environmental education and environmental literacy by providing teachers with access to high quality professional learning opportunities and education resources. It is a program of the California Department of Education.

Integration of EP&Cs into the state curriculum frameworks

California's State Board of Education (SBE) has demonstrated its commitment to environmental literacy by calling for the integration of the EP&Cs into state curriculum frameworks in Science (2016), History-Social Science (2016), and Health (2019). SBE-adopted instructional materials in these content areas must integrate the EP&Cs, and the state's California Science Test (CAST) will, in part, use the EP&Cs as a context for assessing California's Next Generation Science Standards (adopted in 2013), for all students in elementary, middle, and high school grade bands. CAST is a part of the state's accountability system.

Codification of California's EP&Cs into the California Education Code

Senate Bill 720 (Allen, 2018) codified California's EP&Cs into the California Education Code as the state's definition of environmental literacy and directed the State Board of Education (SBE), State Superintendent of Public Instruction, district superintendents, and school boards to work toward all students becoming environmentally literate members of society. It also updated the list of covered concepts to explicitly include environmental justice and climate change. By adopting the NGSS, the State Board guided all California educators to teach about climate change in accordance with the state-adopted standards.

California Science Teachers Association (CSTA) Climate Literacy Summit

In early 2018, the California Science Teachers Association (CSTA) recognized that significant gaps in teacher content knowledge and experience in teaching climate science existed. CSTA, in collaboration with partners from Scripps Institution of Oceanography and the National Aeronautics and Space Administration's Jet Propulsion Laboratory, pioneered the development of a Climate Summit for PK–12 educators and developed grade level units of study aligned to current standards (presented as three-hour short courses), and the production of a special climate edition of the *California Journal of Science Education*. All of the resources developed for this project were made free to the public.

APPENDIX 2.1 (PRE-SERVICE):

Environmental Education/Literacy Single-Subject and Multiple-Subject Pre-Service Surveys

Summary of Environmental Education/Literacy Survey Single-Subject Respondents:

CSU 14
UC 4

Summary of Environmental Education/Literacy Survey Multiple-Subject Respondents

CSU 12
UC 3

SINGLE-SUBJECT AND MULTIPLE-SUBJECT SURVEY QUESTIONS:

1. Which university are you affiliated with?
2. Does your campus offer pre-service candidates with any of the following opportunities to access environmental education/literacy curriculum? (Check all that apply).
   - Courses include curriculum addressing social science, history, mathematics or other content connected with the environment
   - Courses build pre-service teachers' knowledge in the Environmental Principles and Concepts (EP&Cs)
   - Courses include opportunities for pre-service teachers to develop skills in designing activities, lessons, or units connected with the environment
3. Please specify additional relevant information and or details regarding the environmental literacy curriculum in your teacher preparation programs.
4. Does your campus offer pre-service candidates access to technology resources connected with environmental literacy?
5. Please specify additional relevant information and or details regarding the use of technology as it relates to environmental literacy for pre-service candidates.
6. Does your campus offer pre-service candidates access to coursework addressing pedagogy or classroom management as it relates to teaching about the environment or preparation for teaching students in outdoor settings?
7. Please specify additional relevant information and or details regarding access to pedagogical support for pre-service candidates.
8. Does your campus offer pre-service candidates access to community organizations/partners for the building of knowledge and relationships connected to environmental issues?
9. Please specify additional relevant information and or details regarding pre-service candidates' access to community organizations.
10. In thinking about a typical single-subject candidate enrolled in a pre-service teacher preparation program on your campus, how often might the student be exposed to environmental literacy through work assigned in coursework?
11. Please share additional relevant information and or details regarding environmental education/environmental literacy and learning opportunities for students enrolled or planning to enroll in your teacher preparation program.
12. Does your credential program track how many pre-service candidates have a background in environmental studies (high school, college courses or other background)?
13. If yes, what percentage of your pre-service candidates have a background in environmental studies?
14. Would you be willing to talk with us further to provide additional information regarding environmental literacy in your teacher preparation programs?

APPENDIX 2.2 (PRE-SERVICE):

Environmental and Climate Change Literacy Project Pre-Service Resources

- **Advancing Climate Literacy through Investment in Pre-service Educators (ACLIPSE)** Provides in-service teachers, pre-service faculty and their students with opportunities to develop in-depth content knowledge of climate science and climate change.
  http://mare.lawrencehallofscience.org/college-courses/ACLIPSE
- **Bending the Curve: Climate Change Solutions** is an educational program designed by all ten UC campuses and centered on a curriculum designed to empower a million climate champions across the world to solve the climate change problem.
  https://bendingthecurve.ucsd.edu
- **Bioneers** is an innovative nonprofit organization that acts as a hub of social and scientific innovators with practical and visionary solutions for the world's most pressing environmental and social challenges.
  https://bioneers.org/about/partners/
- **Campus as a Living Lab (CALL)**
- **California Commission on Teacher Credentialing**
  https://www.ctc.ca.gov/
- **California Department of Education**
  https://www.cde.ca.gov/
- **California Education and the Environment Initiative (EEI)** supports educators in providing K–12 students with quality instruction in environmental and climate change literacy.
  https://californiaeei.org/
- **Charter College of Education at CSU Los Angeles**
- **Climate Literacy and Education Network (CLEAN)** hosts a high-quality and rigorously reviewed collection of climate and energy educational resources.
  https://cleanet.org/index.html

- **CSU Bakersfield and UC Davis' C-STEM Center**
- **CSU Fresno Strategic Teacher Education Partnership (STEP)** places pre-service undergraduates majoring in Liberal Studies into cohorted courses for a more cohesive and connected interdisciplinary experience.
  http://fresnostate.edu/kremen/liberal-studies/ls-step.html
- **CSU Los Angeles Linked Learning Mobile App**, using a systems approach to include all stakeholders within the environmental Green Pathways community.
  http://www.calstatela.edu/academic/ccoe/linkedlearningcommunity
- **CSU Mathematics and Science Teacher Initiative (MSTI)**
- **CSU San Marcos Elementary Science Education**
- **Knowledge Action Network for Transformative Climate and Sustainability Education and Action (UC-CSU KAN)** has developed a model to scale and intensify UC and CSU undergraduate students' literacy in climate change, climate justice, carbon neutrality/greenhouse gas emissions reductions, and sustainability.
  http://climatechampions.ucop.edu/uc-csu-knowledge-action-network-for-transformative-climate-and-sustainability-education-and-action/
- **Linked Learning** addresses the question of how to support teachers in becoming effective environmental educators and integrating environmental and climate change literacy into their teaching.
  https://www.linkedlearning.org/
- **Monterey Bay Aquarium's** pre-service teachers continuing professional development programs.
  https://www.montereybayaquarium.org/conservation-and-science
- The **Next Generation Science Standards** contain three distinct and equally important dimensions to learning science. These dimensions are combined to form each standard, and each dimension works with the other two to help students build a cohesive understanding of science over time.
  https://www.nextgenscience.org/
- **North American Association for Environmental Education (NAAEE)** works to create a sustainable future for all where environmental and social responsibility drive individual and institutional choices.
  https://naaee.org/
  NAAEE Research library
  https://naaee.org/eepro/research/library
  Standards and guidelines, content, activities and rubrics for each grade level
  https://naaee.org/eepro/publication/guidelines-excellence-series-set and https://naaee.org/our-work/programs/guidelines-excellence
- **Science Education Resource Center (SERC)** hosts curated sets of Earth and environmental science curricular material.
  https://serc.carleton.edu/index.html
  http://www.earthlabs.net/
  https://serc.carleton.edu/integrate/teaching_materials/index.html
- **Tejon Ranch Conservancy** and **Wind Wolves Preserve** help create and offer trainings for teacher candidates and mentor teachers related to the use of technology for the purposes of increasing environmental and climate change literacy.
  http://www.tejonconservancy.org
  https://www.wildlandsconservancy.org/preserve_windwolves.html
- **Zooniverse** enables everyone to take part in research across many fields relating to the sciences, creating opportunities for students to unlock answers and contribute to discoveries.
  https://www.zooniverse.org/

APPENDIX 3.1 (IN-SERVICE):

Updating Existing Resources

There are existing resources that can be updated to better fit and promote California's goals of achieving environmental and climate change literacy for PK–12 students. The California Education and the Environment Initiative (EEI), managed by CalRecycle's Office of Education and the Environment (OEE), uses the state-adopted environmental principles and concepts to frame curriculum units for science and history-social science to help foster environmental and climate change literacy. These curriculum units can be updated to better align with current science standards and better support the inclusion of climate change as an integral part of environmental and climate change literacy.

The EEI Science Units were created before the California Science Framework was updated, using national Next Generation Science Standards (NGSS), but contain useful and relevant resources that can still be integrated to fit today's expectations for science education. Existing units can be examined for how they integrate and build off related scientific concepts, and updated to have a more interdisciplinary approach that addresses climate change. Additional units around climate change issues can also be added for teachers to use in their teaching of environmental and climate change literacy.

The EEI History-Social Science Units similarly address various issues in history and social science, many of which can be more comprehensively approached through an environmental lens that looks at geography, conservation of natural resources, and the causes and effects of climate change. Each of these units can also be updated to be more interdisciplinary and bring into focus more current environmental and climate change issues.

Besides the EEI curriculum, the California Department of Education (CDE) can and should place an emphasis on environmental and climate change literacy for PK–12 education. *A Blueprint for Environmental Literacy*, a report produced by the statewide Environmental Literacy Task Force under California State Superintendent of Public Instruction Tom Torlakson, has been available as a resource since 2015. This report can continue to be used and promoted as a resource that provides a foundation for statewide programs for educators that strengthen environmental and climate change literacy.

APPENDIX 3.2 (IN-SERVICE):

Professional Learning Programs

- **California Global Education Project (CGEP) Teaching for Sustainable Communities: Empowering Eco-literate Global Citizens:** A 5-day institute focused on sustainability and environmental and climate change literacy, global competence, and student agency. The program offers follow-up support for teachers and guidance in creating a student exhibition of learning. This program is offered for K–12 teachers in San Diego, Long Beach, Orange County, the Bay Area, and Northern California.
  http://calglobaled.org/professional-learning
- **CGEP Sustainable Development Goals Workshop:** A one-day workshop on United Nations global goals focused on environmental issues, including climate action, affordable energy, clean water and sanitation, and sustainable cities and communities.
  http://calglobaled.org/professional-learning
- **CGEP Global Book Bags Program:** A one-day workshop for elementary teachers to align literature-based learning activities with environmental principles and concepts, global issues, and environmental justice.
  http://calglobaled.org/global-book-bags/
- **California History-Social Science Project** offers an elementary-focused professional learning institute at CSU Dominguez Hills. This institute models the integration of environmental principles into history-social science and science instruction. Teachers have hands-on time with NGSS-aligned lessons and complementary history-social science lessons that can be taught in tandem in order to reinforce learning in both subjects.
  https://csmp.ucop.edu/chssp
- **California Next Generations Science Standards Rollout 6:** A two-day professional learning course for educators to experience grade appropriate learning resources for environmental and climate change literacy and learn from community-based partners that have resources to support environmental education, presented by the California Next Generations Science Standards Collaborative.
  https://cascience.org/ngss/ngss-collaborative
- **California Science Project** has established two main partnerships to provide models for professional learning for teachers in grades K–5 and 6–12. The Alameda Elementary Environmental Literacy project (AEEL) was designed by the Bay Area Science Project in partnership with Alameda USD to develop a professional learning program for K–5 teachers so they can engage students in three-dimensional learning about the environment that is grounded in the California Next Generation Science Standards and the Environmental Principles and Concepts. The San Fernando Valley Science Project in partnership with the Friends of the Los Angeles River designed a two-week professional learning institute for teachers in grades 6–12 in Los Angeles County. Both programs provide follow-up days throughout the school year to continue supporting environmental and climate change literacy implementation.
  https://csmp.ucop.edu/csp

- **California Science Teachers Association (CSTA) Climate Summit:** A one-day pre-conference and offerings throughout the three-day California Science Education Conference that provides professional learning opportunities for teachers to enrich their content knowledge and receive support around teaching climate science appropriate for their grade level, including advice on accessing and using informal resources.
  https://cascience.org/resources/climate-summit
- **National Geographic "Teaching Global Climate Change in Your Classroom"** is a free online professional learning course for both formal and informal educators.
  https://www.nationalgeographic.org/education/professional-development/courses/
- **San Diego County Office of Education Project Phenomena Summits** are two-day experiences for educators and university scientists to come together to build understanding around environmental phenomena and the role of these phenomena in Next Generations Science Standards science instruction. These summits are held throughout the State of California.
  https://ngss.sdcoe.net/Environmental-Literacy/Environmental-Literacy-Phenomena-Summits/Summit-Design
- **San Mateo County Office of Education (SMCOE) Schools for a Sustainable Future Summit:** A 1-day annual summit that supports educators and the broader community with knowledge, skills, and tools for moving environmental sustainability across a school's Campus and Operations, Curriculum and Instruction, and Community and Culture. It also creates the space for networking, problem solving, and exchanging innovative solutions that are driving environmental and social transformation across school communities.
  https://ngss.sdcoe.net/Environmental-Literacy/Environmental-Literacy-Phenomena-Summits/Summit-Design
- **San Mateo County's Environmental Literacy Community of Practice** is a network of educators and community partners who are brought together by SMCOE's Environmental Literacy Team to network, problem solve, and exchange innovative solutions that drive environmental and social transformation across school communities. This network shares best practices for driving environmental and social transformation across all aspects of an institution, increases communication and collaboration between schools and districts and the community and environmental education partners (including municipal jurisdictions), and provides professional learning programs, including summer institutes.
  https://sites.google.com/smcoe.org/smcoe-environmental-literacy/programs/community-of-practice-cop
- The **American Museum of Natural History's Seminars on Science** are online courses for educators that address various topics in science, including climate change.
  https://www.amnh.org/learn-teach/seminars-on-science

APPENDIX 3.3 (IN-SERVICE):

Professional Learning Resources

- **American Association of Geographers' (AAG) "Teaching About Climate Change"** is a platform with free, online professional learning modules for teachers at the middle and high school levels to develop their content knowledge around global climate change, with special focus on various issues and critical thinking based on grade level.
  http://www.aag.org/cs/teachingclimatechange
- **American Meteorological Society Education Professional Development** offers Earth system science and STEM tuition-free graduate credit courses.
  https://www.ametsoc.org/ams/index.cfm/education-careers/education-program/k-12-teachers/
- **California History-Social Science Project's (CHSSP) *The Source* magazine** includes regular updates on CHSSP programs and sample lesson plans around various history and social science subjects. This magazine offers resources around teaching methods and pedagogy that teachers can use for interdisciplinary teaching.
  https://chssp.ucdavis.edu/source-magazine
- **CHSSP's Free Webinar Series on Environmental Literacy** in History-Social Science, a set of four webinars for educators at all grade levels that demonstrate how environmental issues connect with history and social sciences and offer teaching presentations, lesson activities, and other materials.
  https://chssp.ucdavis.edu/programs/environment
- **California Regional Environmental Education Community (CREEC) Network**, a program coordinated by California Department of Education that fosters regional partnerships to provide teachers with access to high quality professional learning opportunities and resources for environmental and climate change literacy.
  https://www.creec.org/Home/About
- **CLEAN Teleconference and Webinars** are offered Tuesdays at 1 pm EST where members meet in a teleconference to collaborate and share information about their literacy work, upcoming events, opportunities for collaboration or funding. Frequently guest speakers present on the topic of climate and energy literacy.
  CLEAN Network Teleconferences
  https://cleanet.org/clean/community/cln/telecon_schedule.html
  CLEAN Teacher Webinar Series
  https://cleanet.org/clean/community/webinars/webinars.html
- **Climate Generation Professional Development** offers virtual and in-person training opportunities in energy literacy and climate change education, including a Summer Institute for Climate Change Education.
  https://www.climategen.org/what-we-do/education/professional-development/

- **Climate Literacy: The Essential Principles of Climate Science** is a guide developed by an interagency effort involving the National Oceanic and Atmospheric Administration (NOAA) and American Association for the Advancement of Science (AAAS), available in both English and Spanish.
  https://www.climate.gov/teaching/essential-principles-climate-literacy/essential-principles-climate-literacy
- **Climate Literacy & Energy Awareness Network (CLEAN) Collection of Climate and Energy Resources** is a collection of free and ready-to-use learning resources for secondary and higher education classrooms, green-lighted by educators and scientists.
  https://cleanet.org/index.html
- **Common Sense Education** has four recommended free resources for educators, including NASA's Global Climate Change mapping tool, NASA's Eyes on the Earth for children, the Global Oneness Project, and Next Generation Science Standards' Earth-Now data analysis tool.
  https://www.commonsense.org/education/articles/4-free-tools-to-teach-about-climate-change
- **Global Learning and Observations to Benefit the Environment (GLOBE) Program** is an international science and education program that provides students and the public worldwide with the opportunity to participate in data collection and the scientific process, and contribute meaningfully to our understanding of the Earth system and global environment.
  https://www.globe.gov/
- **History-Social Science Content, Literacy, Inquiry, Citizenship:** a statewide network of resources that support the California History-Social Science framework, which includes a compendium and videos for grade-level opportunities to teach environmental and climate change literacy aligned to standards.
  https://californiahss.org/EnvironmentalLiteracy.html
- **Lawrence Hall of Science Toolkit** (https://www.lawrencehallofscience.org/programs_for_schools/lcap_toolkit)
- **NASA's** recommended resources for educators, including professional development courses, workshops, and resources from various vetted organizations that help address the issue of global climate change.
  https://climate.nasa.gov/resources/education/
- **National Center for Science Education's (NCSE) "Dealing with Denial"** teaching resources, which specifically address best practices and tips for educators teaching climate change issues to communities that are resistant to the idea of climate change.
  https://ncse.com/dealingwithdenial
- **National Center for Science Education's (NCSE) Classroom Resources**, including lesson plans on climate change, classroom tips for teaching science, and advice on navigating relationships with administration and teachers to gain support for science education.
  https://ncse.com/classroom-resources
- **National Center for Science Education's (NCSE) Scientist in the Classroom** program, a platform that brings teachers and scientists together to collaborate on science education by bringing a scientist into appropriate classrooms to aid in teaching hands-on, applied science.
  https://ncse.com/scientistinclassroom
- **National Education Association's (NEA) resources** for climate change education, which include teaching resources, useful websites, suggested activities, and lesson plans.
  http://www.nea.org/climatechange
- **National Science Teaching Association's (NSTA) professional development resources**, which include teaching guides, web seminars, and workshops that educators can access to gain content knowledge around various climate change issues.
  https://www.nsta.org/conferences/
- **National Science Teaching Association (NSTA) Learning Center** is an online platform for use when developing professional learning experiences for teachers of science.
  https://learningcenter.nsta.org/
- **NOAA Planet Stewards Education Project** supports educators in the development and implementation of projects involving hands-on activities that conserve, restore, and protect human communities and natural resources.
  https://oceanservice.noaa.gov/education/planet-stewards/welcome.html
- **North American Association for Environmental Education's (NAAEE) eePRO:** an online platform for environmental educators to access professional development opportunities and resources.
  https://naaee.org/eepro
- ***Understanding Climate Change, Grades 7–12*** a book that addresses Next Generation Science Standards through a nine-session module on issues around climate change, published by National Science Teaching Association.
  https://www.nsta.org/store/product_detail.aspx?id=10.2505/9781681406329
- **Zinn Education Project's *A People's Curriculum for the Earth*** is a teaching guide that collects articles, stories, graphics, and more to help illustrate climate change and the environmental crisis, and offers teaching activities for educators to use.
  https://www.zinnedproject.org/materials/peoples-curriculum-for-the-earth

APPENDIX 4.1 (CURRICULUM):

Climate Change Instructional Resources

The UC/CSU system K–12 educators and their partners have a wealth of well-developed, standards-aligned curricula and instructional resources from which to draw in developing pre-service, in-service, elementary, and secondary courses. For example, in 2018, the California SBE adopted science programs from 18 publishers. Each program is NGSS-aligned and incorporates the EP&Cs (https://www.cde.ca.gov/ci/sc/im/adoptedsciprograms2018.asp). NGSS explicitly addresses climate change from middle school to high school and proximally addresses it in all grades. In addition to publications available for purchase, the lists below highlight other free, easily accessible, climate-related instructional resources.

- **Advancing Climate Literacy through Investment in Pre-Service Educators (ACLIPSE)** Grades 6–12 instructional materials and professional learning materials in climate science activities.
  https://mare.lawrencehallofscience.org/college-courses/ACLIPSE/overview
- **Alliance for Climate Education, Our Climate Our Future** Award-winning climate education resource for teachers and students featuring ACE's signature mix of animation, video and interaction, including trivia questions, climate change lesson plans and more.
  https://ourclimateourfuture.org
- **California Department of Education, Instructional Resources, Climate Change** This collection of supplementary curriculum resources can help teach students about global climate change and increase awareness.
  https://www.cde.ca.gov/pd/ca/sc/climatechange.asp
- **California Department of Water Resources** offers resources related to California's climate/water connection.
  https://water.ca.gov/What-We-Do/Education/Climate-Change-Poster
- **California Education and the Environment Initiative** K–12 curriculum that demonstrates how to incorporate the EP&Cs into science and history instruction. While the EEI science units were written prior to NGSS, they include resources that may be harvested for NGSS lessons.
  https://www.californiaeei.org/curriculum/history-social-science-units/
- **California History-Social Science Project** Resources to help students understand current events in relation to their historical context.
  https://chssp.ucdavis.edu/current-context
- **California Science Teacher Association** K–12 learning sequences focusing on phenomena-based teaching and learning.
  https://cascience.org/climate-summit/k-12-learning-sequences/
- **Civic Action Project (CAP)** Project-based learning that connects an issue to public policy then guides students how to take "civic actions" to impact the issue.
  https://crfcap.org/
- **Climate Generation's Climate Change and Energy Curricula** Grades 3–12 curriculum guides and online modules for science and humanities teachers.
  https://www.climategen.org/our-core-programs/climate-change-education/curriculum/
- **Climate Literacy & Energy Awareness Network (CLEAN)** Learning resources, visualizations, videos, and short experiments focused on climate and energy.
  https://cleanet.org/index.html
- **EarthLabs** Earth and environmental lab science courses, NGSS-aligned units illustrate a sequence for learning science concepts through data analysis activities, satellite imagery and computer visualizations, and hands-on experiments that illustrate processes of our Earth system.
  https://serc.carleton.edu/eslabs/index.html
- **Ecorise** A school-based program that empowers youth to tackle real-world challenges in their schools and communities by teaching sustainability, design innovation, and social entrepreneurship.
  https://ecorise.org/about/
- **Energize Schools: A Program of Strategic Energy Innovations** Grades 9–12 project-based learning that engages students in sustainability.
  https://www.energizeschools.org/
- **Global Oneness Project** Aims to connect, through stories, the local human experience related to climate change.
  https://www.globalonenessproject.org/
- **Morningside Center for Teaching Social Responsibility** Lessons and resources to help K–12 educators encourage social responsibility and foster social and emotional learning.
  https://www.morningsidecenter.org/
- **NASA: Global Climate Change** Articles, data, lessons, and interactive components focused on climate change.
  https://climate.nasa.gov/
- **NASA: Jet Propulsion Laboratory** Articles, data, lessons, and interactive components focused on our universe of science, technology, engineering, and math.
  https://www.jpl.nasa.gov/edu/
- **National Climate Assessment (2018), U.S. Global Change Research Program** Assesses the science of climate change and variability and its impacts across the United States, now and throughout this century. Written to help inform decision-makers, utility and natural resource managers, public health officials, emergency planners, and other stakeholders. Thoroughly reviewed by external experts and the general public, as well as the Federal Government, and the National Academies of Sciences, Engineering, and Medicine (NASEM).
  https://nca2018.globalchange.gov/

- **National Wildlife Federation's (NWF) Climate Classroom** Online climate science and solutions curriculum, learning community and education policy development program to help K–16 educators develop skills in and have the tools and public support they need to teach students about the most important environmental subject they will experience throughout their lifetimes.
https://climateclassroom.org/

- **Nature Works Everywhere** Lessons and resources to help students learn the science behind how nature works for us and how we can help keep it running strong.
https://www.natureworkseverywhere.org/

- **NOAA Climate.gov** Science-based, interdisciplinary models of education and public engagement support learners of all levels and foster climate and energy literacy and action.
https://www.climate.gov/

  Climate.gov features a page of information about teaching with the Third National Climate Assessment, including background on the report, learning pathways to help educators utilize key messages and data, region-by-region guides, and other supporting education and communication resources.
https://www.climate.gov/teaching/national-climate-assessment-resources-educators/2014-national-climate-assessment-resources

- **NOAA Climate.gov News and Features** A popular-style magazine for the science-interested public covering topics in climate science, adaptation, and mitigation.
https://www.climate.gov/news-features

- **Project Drawdown** A global research organization that identifies, reviews, analyzes the most viable solutions to climate change, and shares these findings with the world.
http://www.drawdown.org/

- **Project Learning Tree** Curriculum that uses trees and forests as windows on the world to increase students' understanding of the environment and action.
https://www.plt.org/

- **Project Wet** offers water resource education materials that are appropriate for many different age groups and cultures. Includes a climate resilience lesson on environmental and infrastructural changes that can help to mitigate the water-related impacts of climate change in communities and on certain populations.
https://www.projectwet.org/climate

- **Project Phenomena** Phenomena used to provide students personal experiences with observable events where an evidence based explanation can be constructed. Website contains a searchable database of local phenomena and data aligned with NGSS three dimensions and EP&Cs.
http://ngss.sdcoe.net/Phenomena-and-the-NGSS/The-Importance-of-Phenomena

- **Teacher-Friendly Guide to Climate Change** Paleontological Research Institution's book includes both the basics of climate change science and perspectives on teaching a subject that has become socially and politically polarized. For high school Earth science and environmental science teachers with classroom ready information and graphics.
https://priweb.org/index.php/pubs-special/pubs-spec-5813-detail

- **Understanding Global Change and Understanding Science, UC Berkeley** A conceptual framework, systems models, lessons, and assessment tools to guide the design of interdisciplinary global change curricula and to support the exploration of the nature and process of science.
http://www.ucmp.berkeley.edu/ugc-resources/ and
https://undsci.berkeley.edu/

- **U.S. Climate Resilience Toolkit** Website designed to help people find and use tools, information, and subject matter expertise to build climate resilience. Offers information from all across the U.S. federal government in one easy-to-use location.
https://toolkit.climate.gov/

- **World Climate: Climate Change Negotiations Game** Role playing exercise of the UN climate change negotiations for groups. Uses an interactive computer model to rapidly analyze the results of the mock-negotiations during the event. Available in multiple languages.
https://www.climateinteractive.org/programs/world-climate/

- **Young Voices for the Planet Film Series** Empowering children and youth, through uplifting and inspiring success stories, to take an essential role in informing their communities—and society at large, challenging decision-makers, and catalyzing change.
https://www.youngvoicesfortheplanet.com/

NOTES

1. https://cascience.org/ngss/equitable-access-science-education
2. The UCs are already working to emit net zero greenhouse gases from buildings and vehicle fleets by 2025 through their Carbon Neutrality Initiative, so their Climate Action Champions network and Global Climate Leadership Council have been cultivating programs and resources and could be tapped to aid PK–12 educators. Many campuses also have centers devoted to climate change work, such as the Climate and Energy Policy Institute at Berkeley Law, the Center for Climate Science at the Institute for the Environment and Sustainability at UCLA, and the UC Natural Reserve System Climate Modeling Network, which consists of 19 new automated weather and climate monitoring stations operating in UC's Natural Reserves. Faculty could share with PK–12 educators what it is like and what skills future graduates will truly need in order to tackle wicked problems in a high-tech interdisciplinary setting.
3. Currently, there are few incentives (and actually many obstacles) facing untenured faculty who are otherwise motivated to work toward these stated goals.
4. Ensure groups already involved in this work are included at the outset, e.g., the California Science Teachers Association, California Subject Matter Project, the California Environmental Literacy Initiative, select county offices of education, etc.
5. The California Subject Matter Project, led by the University of California Office of the President, was established with the purpose of engaging university faculty and PK–12 educators in collaborative professional learning in regions across the state. Also, PK–12 educators and professional learning providers can work with local universities to engage faculty in learning experiences within the PK–12 classroom (face-to-face or virtually through live video conference, email exchanges, online lectures or TedTalks, etc.) and on college campuses (campus tours, lectures, meetings, programs, events, etc.).
6. In recent years, there has been a significant increase in the number of students taking three or more years of science in high school, as students and families recognize the value of science education for opening doors to future success, including college and career opportunities. This model, however, is currently not financially supported by the State of California, where the Education Code mandates, and the state thus funds, only two years of science (disseminated via mandated block grant). Local Education Agencies (Districts, Charters, etc.) have been able to creatively reallocate money to support additional science coursework (this funding is acquired through the Local Control Funding Formula). Not every Local Education Agency, however, prioritizes expenditure of funds for high school science courses, creating preferential treatment for physical science (chemistry or physics) and biology, often resulting in the reduction or elimination of Earth and Space Science courses, where the strongest explicit connections to climate and human impacts on the environment are found in our state science standards, CA NGSS.
7. This would maximize the ability, on a local level, to increase teacher professional learning in environmental education. This messaging could also include how to prepare and apply for ESSA funds to further support the expansion of environmental education. Resources that can be utilized in the informational campaign already exist through the Lawrence Hall of Science and the National Science Teaching Association. (See Appendix 3.3.)
8. California and its State Board of Education exerted outstanding leadership, being one of the first states to adopt the Next Generation Science Standards (NGSS) in 2013. The subsequent California Next Generation Science Standards (CA NGSS) Systems Implementation Plan (2014) involved a very intentional and careful rollout of the new science standards that resulted in California being the only state in the nation thus far to have a robust science curriculum framework aligned to the CA NGSS (2016) and an innovative state assessment (California Science Test) which went fully operational in 2018. Despite these efforts, implementation of CA NGSS statewide is uneven. Unlike the rollout of Common Core State Standards in English and Mathematics, for the CA NGSS and the other new frameworks (History Social-Sciences, Health, World Languages, etc.) there has never been any targeted financial support from the state to Local Education Agencies (Districts, Charters, etc.) specifically for the implementation of the new standards and frameworks.
9. Funding remains an integral component to creating and sustaining robust, high quality environmental and climate change literacy initiatives and climate change education. Securing specific funding sources helps to ensure consistent funding that can be relied on from year to year for long-term and sustained programs.
10. This reform is enacted using career-themed pathways (e.g., Environmental Science, Transportation, Information Science, Software Design, etc.) where curriculum includes general subject learning outcomes taught in the context of the industry sector theme as well as career and technical education outcomes. More often than not, environmental themes are used for general subject learning as well as for the real-world career outcomes. Linked Learning research shows that students in certified Linked Learning pathways completed more college preparatory courses compared with similar peers in traditional high school programs. Students who entered certified pathways with low prior achievement were 2.1 percentage points less likely to drop out, 3.1 percentage points more likely to graduate, and accumulated 8.9 more credits and 0.9 more college preparatory requirements than similar peers in traditional high school programs. Partnerships are needed with educator preparation programs so that student teacher placements may be made in these settings.
11. In California, we already have a number of groups working this way, e.g., California Science Teachers Association (CSTA); the California Subject Matter Project (CSMP)—which already involves university faculty in the design of professional learning institutes for PK–12 teachers; the California Environmental Literacy Initiative (CAELI); select county offices of education; and more. As a model of localization, one of the Subject Matter Projects—the California History-Social Science Project—will conduct a series of seven regional sessions to bring those with expertise in indigenous knowledge and Native American history to help educators revamp curriculum. Engaging the UC and CSU systems in work of this type will help take this work to scale so more of the 300,000 educators in our system can be reached.

Up-to-date thinking in the sciences and humanities, access to research facilities, and collegial cross-sector discussions will enliven units of study and infuse them with sought-after authentic college and career significance.

In addition to collaborating and coordinating these emergent networks, it would be beneficial to establish core training modules to help universities, community colleges, educators, community-based organizations, and local governments understand each others' basic culture and approach. For example, most teachers could benefit from an introduction to contemporary research methods, and higher education faculty would likely appreciate a primer on the PK–12 public school context. Through these "curriculum hacks," local experts could provide technical assistance to teachers in adapting published curriculum to their own students' interests and lived experience. According to CSTA's recent report on equitable access to science instruction, "Major shifts in policy and resources are necessary to increase time for teacher preparation and collaborative planning to provide instruction that fully delivers on the promise of California's Next Generation Science Standards (CA NGSS)."

12. Every community in California offers resources (personnel, programs, places) to support student learning about the environment. From local water and energy authorities to community-based organizations to city sustainability officers, there are many people willing to talk with teachers and their students. Speakers and programs can be combined with field studies that allow students to observe, record, question, analyze, and problem-solve in their communities, local parks or public spaces, and through outdoor education experiences.
13. The term Universal Design for Learning (UDL) means a scientifically valid framework for guiding educational practice that provides flexibility in the ways: information is presented, students are engaged, and students respond or demonstrate knowledge and skills, reduces barriers in instruction, provides appropriate accommodations, supports, and challenges, and maintains high achievement expectations for all students, including students with disabilities and students who are limited English proficient. Provided by the Higher Education Opportunity Act of 2008 (HEOA). https://mtsac.libguides.com/udl
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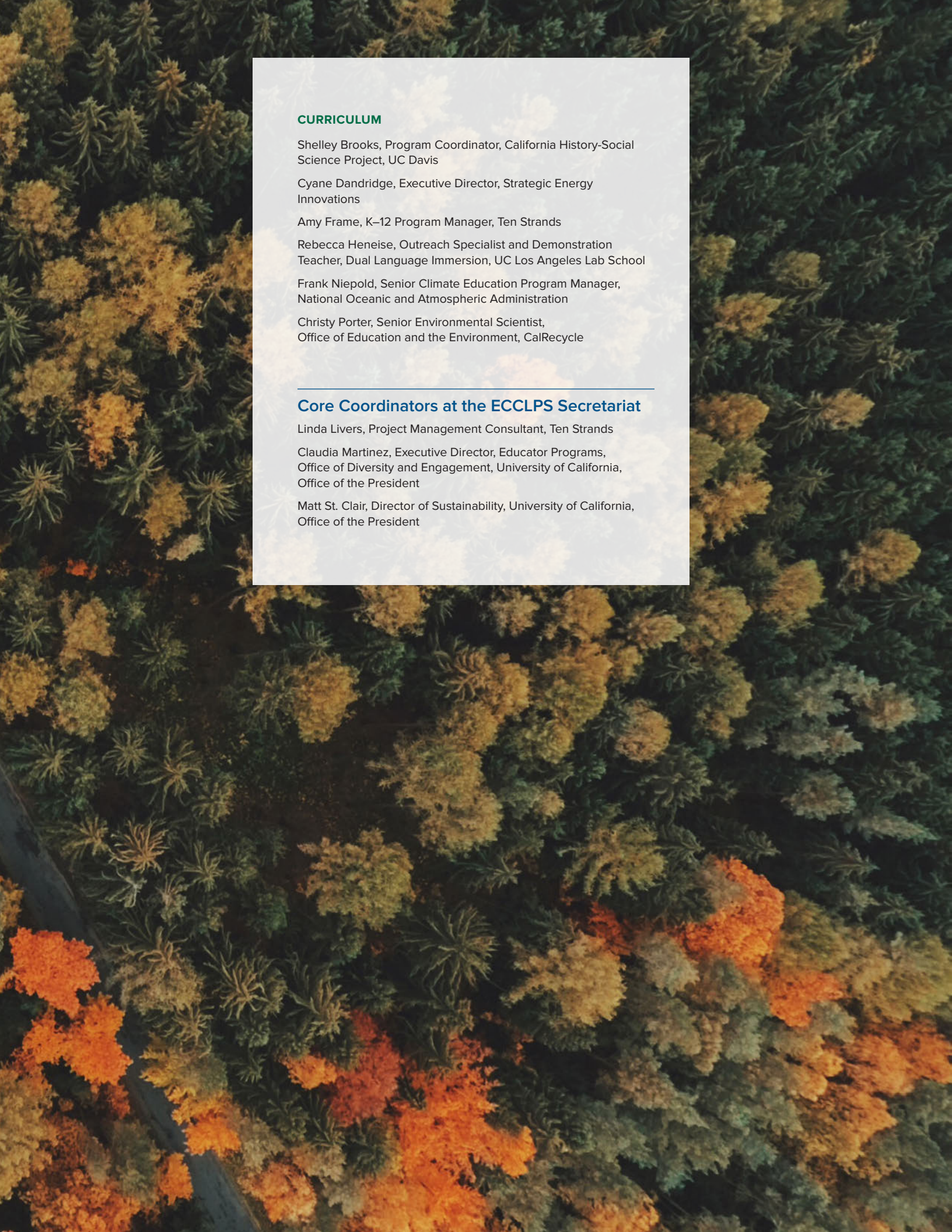

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