PETITION of

Youth Petitioners
and Alaska Youth for Environmental Action

to the

Alaska Department of Environmental Conservation

For the promulgation of a rule to ensure an effective emissions reduction trajectory that is based on best climate science and will achieve safe atmospheric concentrations of carbon dioxide by 2100.

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On Behalf of Petitioners

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Pursuant to AS §§ 44.62.220, Alaska youth, including Essau S[redacted], Cade T[redacted], Macy Rae K[redacted], Linnea L[redacted], Jasmine I[redacted], Nathan B[redacted], Tasha E[redacted], Summer S[redacted], Liszka B[redacted], Lila S[redacted], Cecily S[redacted], Ananda [redacted] L[redacted], Griffin P[redacted], Lexine D[redacted], and Solomon S[redacted], and Alaska Youth for Environmental Action, a project of the Alaska Center Education Fund, a 501(c)(3) non-profit corporation (collectively, "Petitioners"), hereby petition the Alaska Department of Environmental Conservation ("the Department") for the adoption of a regulation under the Department's authority and pursuant to its obligations under the Constitution of the State of Alaska, the Public Trust Doctrine, and statutes and regulations, to protect the rights and common welfare of present and future generations of Alaskans by implementing an enforceable, effective carbon dioxide ("CO_2") and GHG reduction strategy that is based on the best climate science and is aimed at ensuring that Alaska does its part to restore the concentration of CO_2 in the atmosphere to 350 parts per million ("ppm") by 2100. Such a rule is necessary in order to ensure that the worst impacts of climate change and ocean acidification are avoided and do not cause further catastrophic and irreversible harm to present and future generations of Alaskan youth.

Substance of the regulation requested: Specifically, Petitioners request that the Department promulgate the rule proposed below:

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Proposed Rule

PREAMBLE:
Human activity, primarily from the combustion of fossil fuels, has increased the global concentration of greenhouse gases in the atmosphere. Science informs us that the increase in atmospheric carbon dioxide (CO_2) concentrations has already warmed the global climate system and acidified the oceans, causing significant adverse effects to human health, safety, and welfare and Earth's natural systems. Left unabated, global climate destabilization and ocean acidification will have long-term catastrophic effects on human systems and the habitability of Alaska and the nation. The best climate science indicates that the global concentration of CO_2 in the atmosphere must be rapidly reduced to no more than 350 parts per million (ppm) to protect the climate system humans depend upon. If global CO_2 emissions are reduced by at least 85% from 1990 levels by 2050, and continue to decline thereafter, and there is significant reforestation around the world, global atmospheric CO_2 levels are likely to stabilize at 350 ppm by 2100 thus avoiding the most severe impacts of climate destabilization. These targets reflect the global average emissions reductions required to remedy our climate emergency without accounting for the differentiated and equitable responsibilities of individual states and their historic contribution to carbon pollution.

The goal of this rule is to protect the rights of present and future generations of all Alaskans, including Alaska Natives, to a healthy atmosphere and stable climate system, and to safeguard their inheritance of the legacy and heritage of the State of Alaska. Specifically, this rule is intended to: (1) fulfill the State's Public Trust obligation to prevent waste and substantial impairment of trust resources (2) achieve Alaska's constitutional "principles that all persons have

a natural right to life, liberty, [and] the pursuit of happiness…[and] that all persons are equal and entitled to equal rights, opportunities, and protection under the law;"[1] (3) realize Alaska's constitutional obligation "to secure and transmit to succeeding generations our heritage of political, civil and religious liberty;"[2] (4) to carry out the Department's statutory duty "to conserve, improve, and protect [Alaska's] natural resources and environment and control water, land, and air pollution, in order to enhance the health, safety, and welfare of the people of the state and their overall economic and social well-being;"[3] and (5) to fulfill the Department's statutory duty to "manage the basic resources of water, land, and air to the end that the state may fulfill its responsibility as trustee of the environment for the present and future generations."[4]

DEFINITIONS:

1. **"Best Climate Science"** means:
    a. the most current scientific knowledge and understanding from qualified climate system scientists on safe levels of atmospheric CO_2 and other greenhouse gases and their near-term and long-term impacts; and
    b. the most current scientific knowledge and understanding from qualified climate system scientists as to the greenhouse gas emissions reductions and CO_2 sequestration required to stabilize the climate system and preserve a habitable and safe climate system for future generations.
2. **"Carbon Budget"** means the total amount of CO_2 emissions that can be released over a specific time frame while ensuring a return to the maximum safe limit of 350 ppm of CO_2 by 2100, or a lower level as may be determined by the best climate science.
3. **"CO_2"** means carbon dioxide.
4. **"Consumption Emissions and Inventory"** means a greenhouse gas inventory focused on all emissions associated with materials and services, including electricity and fuels, consumed in Alaska, including estimates of embedded emissions associated with the life cycle of such materials and services. These emissions are included regardless of whether they physically originate in Alaska. A consumption-based inventory uniquely counts out-of-state emissions associated with producing and transporting the products, services, and fuels consumed in Alaska. It also counts emissions associated with producing and transporting fuels that are used to generate electricity consumed in Alaska.
5. **"Department"** means the Alaska Department of Environmental Conservation.
6. **"Greenhouse Gas" or "GHG"** means any gas that has contributed to anthropogenic global warming, including but not limited to carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexaflouride.
7. **"In-boundary Emissions and Inventory"** means the greenhouse gas inventory focused on all emissions produced within the state and also includes emissions associated with the extraction, transportation, refinement, and combustion of fossil fuels extracted in Alaska, whether such transportation, refinement, or combustion occurs within or outside of the state. In-boundary emissions inventories exclude many of the emissions associated with materials and goods produced outside, and imported into, the state.

[1] ALASKA CONST. art. I, § 1.
[2] ALASKA CONST. Preamble.
[3] ALASKA STAT. ANN. § 46.03.010(a).
[4] ALASKA STAT. ANN. § 46.03.010(b).

8. **"$MMTCO_2$"** means million metric tons CO_2.
9. **"$MMTCO_2e$"** means million metric tons CO_2 equivalent.
10. **"PPM"** means parts per million atmospheric concentration.

EMISSION REDUCTIONS:

1. The Department shall regulate stationary and mobile sources of CO_2 emissions and the extraction of fossil fuels within the State of Alaska to:
    a. Ensure that Alaska reduces its total in-boundary and consumption CO_2 emissions to at least 85% below 1990 levels by 2050 in order for its emission reductions to be consistent with the global average emission reductions required to return global atmospheric CO_2 to 350 ppm by the end of the century;
    b. Establish interim benchmarks requirements for minimum levels of emission reductions for at least the years 2020, 2030, and 2040 to guide progress toward the 2050 reduction requirement;
    c. Ensure that Alaska's in-boundary CO_2 emissions are reduced by at least 8.5 percent per year beginning in 2018; and
    d. Prepare a numerical statewide goal or "carbon budget," taking into account both in-boundary and consumption emissions, in order to meet the requirements of subsections (a) through (c) of this section so that Alaska may do its share in achieving 350 ppm of CO_2 in the atmosphere by the year 2100.

CARBON ACCOUNTING AND INVENTORY:

2. The Department shall provide an accounting to Alaska citizens of its management of the atmospheric trust asset by publishing annual progress reports on statewide GHG emissions measured in both $MMTCO_2$ and $MMTCO_2e$. These reports must include an accounting and inventory for each and every substantial source of GHG emissions within Alaska, including, but not limited to:
    a. in-boundary emissions from the transportation, industrial, commercial, institutional, residential, electrical, agricultural, and waste sectors; and
    b. consumption emissions associated with Alaskans' consumption of goods, services, and materials imported into Alaska.

    Reports must be available to the public no later than January 31 of each year, beginning in the year 2018, with a lag time of no more than one year (i.e., the 2018 report should contain emissions data from 2017).

CLIMATE ACTION PLAN:

3. Within six months of adoption of these regulations, the Department, with input from stakeholders, shall adopt a Climate Action Plan to meet the reduction requirements specified herein. The Department, with input from stakeholders, shall amend the Climate Action Plan as necessary to address any adjustments to the reduction requirements and interim benchmarks affected by revisions to these regulations within six months of such revisions.

REVISIONS:

4. Two years after the effective date of these regulations, and every five years thereafter until 2050, the Department shall amend these regulations to adjust the reduction requirements and interim benchmarks as necessary to assure that the State is reducing its greenhouse gas emissions in a manner that is consistent with the best climate science, taking into account the State's equitable responsibility for staying within the global 350 ppm carbon budget.

RECOMMENDATIONS TO THE ALASKA LEGISLATURE:

5. Promptly after the adoption of these regulations, the Department shall recommend to the Legislature the adoption of a statute requiring the emissions reductions, interim benchmarks, carbon accounting and inventory, and Climate Action Plan required hereby. Promptly after any amendment to the emissions reductions and interim benchmarks required hereby, the Department shall recommend to the Legislature amendments to such statute consistent with such regulatory amendments.

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Reasons for Petitioners Request: The requested regulation is necessary for the Department to fulfill its Public Trust, constitutional, statutory, and regulatory obligations to protect the rights of present and future generations of all Alaskans, including Alaska Natives, from the worst impacts of catastrophic climate change. The reasons why Petitioners' proposed regulation is needed are more fully detailed in the Public Comments of Youth Petitioners filed by Petitioners concurrently with this petition ***and the Exhibits thereto***. These Comments, as well as all materials cited to and relied upon in this Petition for Rulemaking and in the Public Comments of Youth Petitioners, are hereby incorporated by reference into the official administrative record as though fully set forth herein. If the Department requires copies of these materials, please inform Petitioners. Otherwise, because all materials cited are publicly available, Petitioners assume that the materials are part of the official administrative record.

ADEC Authority: The Department is the designated trustee charged with implementing the State's policy to "*conserve, improve, and protect its natural resources and environment* and control water, land, and air pollution, in order to enhance the health, safety, and welfare of the people of the state," AS § 46.03.010(a), "to improve and coordinate the environmental plans, functions, powers, and programs of the state," AS § 46.03.010(b), and to "manage the basic resources of water, land, and air *to the end that the state may fulfill its responsibility as trustee of the environment for the present and future generations*." *Id.* (all emphasis added). The Alaska Legislature has explicitly granted the Department authority to "adopt regulations necessary to carry out the purposes of this chapter," including, without limitation, regulations for the "control, prevention, and abatement of air, water, or land, or subsurface land pollution," and other regulations "for the implementation of the policy declared in AS § 46.03.010." AS § 46.03.020(10). Moreover, under AS 44.46.020(a)(4), the Alaska Legislature has provided the Department with a clear mandate: the Department *shall* "take actions that are necessary and proper to further the policy declared in AS 46.03.010." The adoption and implementation of Petitioners' proposed regulation would further each of the statements of policy declared in AS 46.03.010.

Having been entrusted by the legislature as the principal state entity for protection of Alaska's natural heritage and legacy, and charged with the "*primary responsibility* for the adoption and enforcement of regulations setting standards for the prevention and abatement of all water, land, subsurface land, and air pollution, and other sources or potential sources of pollution of the environment," (AS 44.46.020(a)(2) (emphasis added)), the Department has both the authority and the duty to adopt Petitioners' proposed rule. The legislature has similarly tasked the Department with "*primary responsibility* for coordination and development of policies, programs, and planning related to the environment of the state and the various regions of the state." AS § 44.46.020(a)(1) (emphasis added)).

In addition to its general authority and duties with respect to the protection of Alaska's natural resources and the health, safety, and welfare of the people of the state, the Alaska legislature has explicitly granted the Department authority to adopt regulations "establishing ambient air quality standards [and] emissions standards…" under the federal Clean Air Act, AS § 46.14.010(a), directing the Department to "adopt regulations to address substantive and procedural elements of the emission control permit program…." AS § 46.14.140(a). Similarly, the legislature has provided the Department with authority to "provide, by regulation, for the control of emissions from motor vehicles." AS § 46.14.510(a).

Finally, consistent with its statutory mandate, the Department itself has publicly affirmed its duty to prevent further GHG-caused damage: "**It's a DEC duty not only to react / mitigate, but to act to prevent and to control damage to the environment caused by greenhouse gases**."[5] Adopting Petitioners' proposed rule would allow the Department to fulfill this acknowledged duty.

[5] *See Presentation to Alaska Climate Impact Assessment Commission*, ALASKA DEP'T OF ENVTL CONSERVATION, 66 (Jan. 24, 2007), https://dec.alaska.gov/air/doc/aciac_jan07-1pg-c.pdf [hereinafter *ADEC Presentation*] (emphasis in original) (As the basis for this duty, ADEC cites ALASKA STAT. § 44.46.020(a)(3) ("promote and develop programs for the protection and control of the environment of the state") and ALASKA STAT. § 46.03.010 ("conserve, improve, and protect [Alaska's] natural resources and environment . . . in order to enhance health, safety and welfare").).

Public Comments of Youth Petitioners

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

Alaska is on the frontlines of climate change. Anthropogenic climate change and ocean acidification are the greatest threats facing human civilization, and Alaska is already experiencing the increasingly severe impacts of these crises. Due to the persistence of long-lived greenhouse gases in the atmosphere, especially carbon dioxide ("CO2")[6] the burdens of climate change will be borne most heavily by today's youth and by future generations. Given the urgency of the climate crisis, Alaskan youth from across the state have joined with Alaska Youth for Environmental Action, a project of the Alaska Center Education Fund, a 501(c)(3) non-profit corporation (collectively, "Petitioners") to petition the Alaska Department of Environmental Conservation ("ADEC" or the "Department") to adopt a rule to ensure that Alaska does its fair share to restore the climate system to a state stable enough to maintain their, and future generations', fundamental rights.

Under the Public Trust Doctrine, and as an agency of the State of Alaska, ADEC holds Alaska's natural resources, including water, air, and wildlife, in trust for present and future generations of Alaskans. As trustee, ADEC has an obligation to manage Public Trust resources "for the common good of the public as beneficiary."[7] ADEC's duties as trustee include protecting the air and atmosphere from substantial impairment.[8] The framers of the Alaska Constitution "sought to enshrine in the state the constitutional principle that the resources of Alaska must be managed for the long-run benefit of the people as a whole – that is, the resources

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[6] *See* James Hansen et al., *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, PLOS ONE 10 (2013), http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0081648 [hereinafter *Assessing "Dangerous Climate Change"*].

[7] *Baxley v. State*, 958 P.2d 422, 434 (Alaska 1998) (public trust doctrine "provides that the State holds certain resources (such as wildlife, minerals, and water rights) in trust for public use, 'and that the government owes a fiduciary duty to manage such resources for the common good of the public as beneficiary.'" (quoting *McDowell v. State*, 785 P.2d 1, 16 n.9 (Alaska 1989)).

[8] *See Kanuk ex rel. Kanuk v. State, Dept. of Natural Resources*, 335 P.3d 1088, 1102 (Alaska Sept. 12, 2014) (Alaska Supreme Court noted that the "Alaska Legislature has already intimated that the State acts as trustee with regard to the air just as it does with regard to other natural resources;" and in n. 78, the Court further noted that the "legislature declared in AS 46.03.010(b) that it is "the policy of the state . . . to develop and manage the basic resources of water, land, *and air* to the end that the state may fulfill *its responsibility as trustee of the environment for the present and future generations*." (Emphasis in original); ALASKA STAT. 46.03.010(a) similarly provides that "[i]t is the policy of the state to conserve, improve, and protect its natural resources and environment and control water, land, and air pollution, in order to enhance the health, safety, and welfare of the people of the state and their overall economic and social well-being."). *See also Juliana v. United States*, 217 F.Supp.3d 1224, 1255 n. 10 (D. Or. 2016) (denying motions to dismiss atmospheric public trust claims in light of allegations of impairment of aquatic resources through atmospheric degradation, stating "[t]o be clear, today's opinion should not be taken to suggest that the atmosphere is not a public trust asset" and listing numerous authorities indicating existence of atmospheric public trust); *Foster v. Wash. Dep't of Ecology*, No. 14-2-25295-1 SEA, 2015 WL 7721362, slip. op. at 8 (Wash. Super. Ct. Nov. 19, 2015), https://static1.squarespace.com/static/571d109b04426270152febe0/t/57607fe459827eb8741a852c/1465941993492/15.11.19.Order_FosterV.Ecology.pdf (finding that public trust duties extend to protection of the atmosphere by virtue of its connection to aquatic resources: "The navigable waters and the atmosphere are intertwined and to argue a separation of the two, or to argue that GHG emissions do not affect navigable waters is nonsensical.").

of the state must be managed as a public trust."[9] Under the Alaska Constitution, the State must utilize its resources "for maximum use *consistent with the public interest*" in conservation and preservation of fundamental rights.[10] The Alaska Legislature also codified the Public Trust in the state's statutory code.[11] The State has "responsibility as trustee of the environment for the present and future generations."[12] The legislature has provided ADEC with the clear mandate to act as trustee of Alaska's natural resources. Pursuant to the federal and Alaskan constitutions, ADEC is further obligated to manage the natural resources in its care, and upon which Petitioners rely, in a manner that does not deprive Petitioners of their fundamental rights to life, liberty, and property and in a manner that does not discriminate against Petitioners and other Alaska youth in favor of older generations and short-term interests.

Despite these clear mandates, ADEC is failing in its responsibilities as trustee to protect the Public Trust resources on which Petitioners' lives and well-being rely. Rather than taking action to address the climate crisis, the State of Alaska, including ADEC, has actively exacerbated the climate crisis by permitting, authorizing, and incentivizing fossil fuel development, extraction, transportation, and combustion while failing to abate and reduce the state's greenhouse gas emissions. Youth Petitioners are already experiencing climate change impacts with devastating effects on Alaska's Public Trust resources. These impacts threaten Petitioners' cultural identities, subsistence practices, personal security, and wellbeing as Alaskans. Between them, these 15 youth Petitioners are experiencing a host of alarming impacts, including, but not limited to, loss of important glacier ecosystems; changing availability of subsistence resources like shellfish, caribou, and seal; ocean acidification; increasing health impacts, including asthma; more frequent and severe heatwaves and wildfires; loss of traditional knowledge due to the rapid change from environmental conditions experienced by previous generations; and an urgent need to relocate entire communities due to sea level rise, storm surges, and permafrost melt. These impacts are already severe, and are only predicted to intensify as the climate crisis worsens. It is increasingly urgent that the Department delay no longer and immediately fulfill its obligation to promulgate a rule to reduce the state's GHG emissions according to the best climate science.

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[9] Gordon S. Harrison, Alaska's Constitution: A Citizen's Guide, 129 (Alaska Legislative Affairs Agency, 5th ed. 2012), available at http://w3.legis.state.ak.us/docs/pdf/citizens_guide.pdf [Hereinafter A Citizen's Guide].

[10] ALASKA CONST. art. VIII, § 1 (emphasis added); Harrison, A Citizen's Guide, supra note 9 at 131. (The meaning of the phrase 'consistent with the public interest' is found elsewhere in [Article VIII]. For example, it means that the principles of conservation must govern resource management (Sections 2 and 4) [and] that everyone should be treated equally by management rules, particularly rules adopted in the interests of conservation that limit the access of some groups to certain resources (Sections 3, 15, 16 and 17). . . .The delegates wanted the state's resources developed, not plundered.").

[11] *Owsichek v. State*, 763 P.2d 488, 495 (Alaska 1988) (public trust doctrine incorporated into Art. VIII, Sec. 3 of Alaska Const. to "impose upon the state a trust duty to manage the fish, wildlife and water resources of the state for the benefit of all the people"); ALASKA CONST. art. VIII, § 3 ("Wherever occurring in their natural state, fish, wildlife, and waters are reserved to the people for common use."). Harrison, A Citizen's Guide, supra note 9 at 129, 131; (The meaning of the phrase 'consistent with the public interest' is found elsewhere in [Article VIII]. For example, it means that the principles of conservation must govern resource management (Sections 2 and 4) [and] that everyone should be treated equally by management rules, particularly rules adopted in the interests of conservation that limit the access of some groups to certain resources (Sections 3, 15, 16 and 17). The delegates wanted the state's resources developed, not plundered."); ALASKA CONST. art. VIII, § 1 (emphasis added).

[12] *See* ALASKA STAT. § 46.03.010(b).

Government-requested, Alaska-specific, climate change assessments have been conducted for over 15 years – all of which indicate that Alaska's greenhouse gas emissions must be reduced to mitigate climate change – and ADEC long-ago went on record as having the authority and owing the duty to regulate Alaska's GHG emissions. Still, the State of Alaska has yet to adopt any policy aimed at addressing and alleviating the dangers climate change poses to Alaska's youth, its posterity, and the natural resources and environment on which their lives depend.

The best climate science,[13] upon which Petitioners' base their rule, indicates that global atmospheric CO_2 concentrations must be reduced to 350 ppm by century's end in order to avoid the most catastrophic and irreversible impacts of climate change and ocean acidification.[14] If global CO_2 emissions are reduced by at least 85% from 1990 levels by 2050, and continue to decline thereafter, and there is significant reforestation around the world (approximately 100 gigatons of carbon drawdown must happen through reforestation), global atmospheric CO_2 levels are likely to stabilize at 350 ppm by 2100.[15] In order to meet this target, CO_2 emissions must be reduced globally by an adequate margin each year.[16] As of 2018, at least an 8.5% reduction in emissions from Alaska, and the rest of the world, in conjunction with significant drawdown of atmospheric CO_2 concentrations through reforestation and other sequestration methods, would be necessary to stabilize the atmospheric concentration of CO_2 at 350 ppm by 2100.[17] These targets reflect the global average emissions reductions required to remedy our climate emergency without accounting for the differentiated and equitable responsibilities of individual states, like Alaska, and their historic contribution to carbon pollution. The U.S. is responsible for the largest global share of historic CO_2 emissions, the second-largest share of current emissions, and the largest per capita share of current emissions. Alaska per capita emissions, in turn, are among the very highest in the country. As such, when equitable consideration is given to Alaska's historic and ongoing contribution to the current climate crisis relative to other states and countries, a requirement that Alaska reduce its emissions by the standard applicable on a global scale without regard to its historic responsibility is not unfair to Alaska.

By taking affirmative actions that allow GHG emissions to continue at dangerous levels, such as permitting and authorizing fossil fuel development, extraction, transportation, and combustion, and by failing to take sufficient action to ensure public safety in the face of

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[13] **Petitioners incorporate by reference into the official administrative record all materials cited to and relied upon in these Comments. If the Department requires copies of these materials, please inform Petitioners. Otherwise, because all materials cited are publically available, Petitioners assume that the materials are part of the official administrative record.**

[14] *Assessing "Dangerous Climate Change" supra* note 6, at 1, 5, 10, 17–18; James Hansen et al., *Ice Melt, Sea Level Rise and Superstorms; Evidence from Paleoclimate Data, Climate Modeling, and Modern Observations that 2°C Global Warming Could be Dangerous*, 16 ATMOS. CHEM. & PHYS. 3761, 3801 (2016) https://www.atmos-chem-phys net/16/3761/2016/acp-16-3761-2016.pdf [hereinafter *Ice Melt, Sea Level Rise and Superstorms*].

[15] *Assessing "Dangerous Climate Change*," *supra* note 6; Declaration of Dr. James E. Hansen in Support of Our Children's Trust et. al.'s "Submission to the U.N. Committee on the Rights of the Child Regarding States Obligations, Children's Rights, and Climate Change" ¶ 68 (August 19, 2016) https://static1.squarespace.com/static/571d109b04426270152febe0/t/576195822fe1316f09d2ed89/1466013077359/15.08.12.HansenExpertDecSupportingYouth.pdf [Hereinafter Hansen 2016 Declaration].

[16] *Assessing "Dangerous Climate Change," supra* note 6, at 1, 5, 10, 17–18.

[17] Hansen 2016 Declaration, *supra* note 15, at ¶ 68.

dangerous climatic changes, the state, including ADEC, is violating its governmental duties to ensure public safety and welfare, safeguard Public Trust resources, and protect Petitioners' fundamental constitutional rights. The people of Alaska, especially its youth, including Petitioners, and future generations, cannot wait any longer for the state to take action to protect their rights.

II. PROCEDURAL HISTORY

In May 2011, six Alaskan youth, including youth Petitioner Ananda [redacted], filed suit against the State of Alaska, Department of Natural Resources, seeking declaratory and equitable relief.[18] The youth plaintiffs alleged they had been personally harmed by the impacts of climate change and asserted the State of Alaska breached its Public Trust duties under Article VIII of the Alaska Constitution by failing to "protect the atmosphere from the effects of climate change and secure a future for Plaintiff's and Alaska's children."[19] Youth plaintiffs sought a declaratory holding that the atmosphere is a Public Trust resource that the state has an affirmative fiduciary duty to protect and preserve and that the state failed to fulfill its Public Trust Duties with respect to the atmosphere.[20] Additionally, youth plaintiffs sought equitable relief in the form of a court order directing the state to "reduce carbon dioxide emissions from Alaska by at least 6% per year from 2013 through at least 2050" and to "prepare a full and accurate accounting of Alaska's current carbon dioxide emissions and to do so annually thereafter."[21]

After finding that the youth plaintiffs had standing and that the State of Alaska's sovereign immunity did not bar their claims,[22] the Alaska Supreme Court recognized the constitutional nature of the Public Trust Doctrine[23] and noted that "the Alaska Legislature has already intimated that the State acts as trustee with regard to the air as it does with regard to other natural resources."[24] The Court found that the existence of Alaska's atmospheric Public Trust is indicated by the text of the Alaska Department of Environmental Conservation's organic statute, noting that "it is 'the policy of the state…to develop and manage the basic resources of water, land, *and air* to the end that the state may fulfill *its responsibility as trustee of the environment for the present and future generations*.'"[25] Ultimately, however, the Court ruled that youth plaintiffs' claims for equitable relief requesting a court-ordered emissions reduction strategy presented non-justiciable political questions involving "science- and policy-based

[18] *Kanuk ex rel. Kanuk v. State, Dept. of Natural Resources*, 335 P.3d 1088, 1091 (Alaska Sept. 12, 2014).
[19] *Id.*
[20] *Id.*
[21] *Id.* (The 6% annual emissions reductions figure requested by youth plaintiffs in *Kanuk ex rel. Kanuk* represented the emissions reductions then necessary, according to the best climate science, to avoid the worst and most catastrophic impacts of climate change had an effective emissions reduction strategy been implemented in 2013. The requisite annual rate of emissions reductions rate increases every year effective action to address climate change is not taken. Therefore, Petitioners' requested annual rate of emissions reductions for a strategy implemented in 2018 is greater than that requested by youth plaintiffs in *Kanuk ex rel Kanuk.* If Alaska delays implementation of this rule, the annual rate of reductions will need to be further increased according to the best climate science.)
[22] *Id.* at 1092–96.
[23] *Id.* at 1099 ("That we interpret the public trust doctrine in a constitutional context is well established.")
[24] *Id.* at 1102.
[25] *Id.* at 1102 n. 78 (emphasis in original) (quoting AS § 46.03.010(b)).

inquiry…better reserved for executive-branch agencies or the legislature."[26] The court noted that these "underlying policy choices are not [the judiciary's] to make *in the first instance*."[27]

In keeping with the pronouncements of the Alaska Supreme Court as to the proper governmental body to decide issues of climate change policy "in the first instance," youth Petitioners now bring their Petition for adoption of regulations before the Alaska Department of Environmental Conservation, the executive branch agency charged with "*primary responsibility* for the adoption and enforcement of regulations setting standards for the prevention and abatement of all water, land, subsurface land, and air pollution, and other sources or potential sources of pollution of the environment."[28]

III. THE PETITIONERS

This petition is brought by 15 Alaskan youth who reside in 12 communities across the state, ranging in age from 5 to 21 years old. Each petitioner is already experiencing the alarming and substantial impacts of a changing climate resulting from increasing levels of CO_2 in the atmosphere. Between them, these 15 youth Petitioners are experiencing a host of alarming impacts, including, but not limited to, loss of important glacier ecosystems; changing availability of subsistence resources like shellfish, caribou, and seal; ocean acidification; increasing health impacts, including asthma; more frequent and severe heatwaves and wildfires; loss of traditional knowledge due to the rapid change from environmental conditions experienced by previous generations; and an urgent need to relocate entire communities due to sea level rise, storm surges, and permafrost melt. These impacts are already severe, and are only predicted to intensify if no meaningful action is taken to reduce CO_2 emissions. Youth Petitioners include:

Esau S[redacted], Age 20, Shishmaref

Solomon S[redacted], Age 15, Kivalina

Macy Rae K[redacted], Age 21, Kotzebue

Tasha E[redacted], Age 18, Juneau

Lila S[redacted], Age 5, Homer

Cecily S[redacted], Age 7, Homer

Liszka B[redacted], Age 17, Anchorage

Cade T[redacted], Age 18, Dutch Harbor

Summer S[redacted], Age 16, Unalakleet

Jasmine I[redacted], Age 17, Petersburg

Nathan B[redacted], Age 17, Fairbanks

Linnea L[redacted], Age 14, Gustavus

Lexine D[redacted], Age 8, Fairbanks

Griffin P[redacted], Age 20, Seward

Ananda [redacted] L[redacted], Age 7, Anchorage

[26] *Id.* at 1099.
[27] *Id.* at 1098 (emphasis added).
[28] ALASKA STAT. ANN. § 44.46.020(a)(2) (emphasis added).

These youth petitioners are joined in their rulemaking request by the organization Alaska Youth for Environmental Action (AYEA), a project of the Alaska Center Education Fund, a 501(c)(3) non-profit corporation. AYEA's members are a dedicated group of youth committed to training and supporting youth-led environmental, community action projects and campaigns.

AYEA seeks to develop a network of young Alaskan leaders, provide opportunities for those leaders to gain the skills and knowledge needed to be effective advocates, and then provide support for youth-driven campaigns. Since 1999, AYEA members have advocated for a safer, cleaner environment for all Alaskans.

AYEA has been a consistent voice calling for meaningful action on climate change for over a decade. In 2005, AYEA teens gathered to learn more about the climate change impacts youth experience throughout the state, and wrote a "Letter to our Leaders" demanding that Alaska reduce its greenhouse gas emissions and promote more renewable energy in the state. This letter developed into a youth petition signed by 5,000 Alaskan youth and 150 villages and cities throughout Alaska. Following the 2005 petition, AYEA continued to promote solutions for the increasing impacts of climate change on Alaskan youth, and in 2006 launched the "3-2-1 Efficiency" campaign encouraging Alaskan households to do their part to reduce greenhouse gas emissions. In 2008 AYEA teens recognized that, "as global warming threatens our way of life, landfill space becomes decreasingly available" and implemented a campaign to minimize waste, particularly plastic bags. 2009-2010 marked AYEA's Renewable Energy Campaign where youth lobbied for a $50 million appropriation by the State of Alaska for renewable energy development. AYEA's work continues to have a climate focus. Since 2014, sixteen AYEA members, including four Petitioners, have become Arctic Youth Ambassadors.

AYEA's efforts since 2015 have been targeted at creating meaningful climate change action. In 2015, AYEA members supported the President's Clean Power Plan for the nation, encouraging Alaska to follow the initiative by reducing carbon emissions 30% by 2030. AYEA teens collected over 1,300 petitions in support of emissions reductions, and engaged in climate advocacy with the Governor, Lieutenant Governor, and state legislators. Petitioners now call upon ADEC to fulfill its Public Trust, constitutional, statutory, and regulatory duties by adopting the proposed rule.

IV. THE RESPONDENTS

In 1971, the Alaska Legislature formed the Alaska Department of Environmental Conservation ("ADEC" or "the Department"). The legislature set out the Department's mission in its organic statute as follows: "to conserve, protect and improve Alaska's natural resources and environment and control water, land and air pollution in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well-being."[29] The Department's organic statute also specifies that the Department effectuate the state's policy to

[29] *DEC History*, ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION, OFFICE OF THE COMMISSIONER, *available at* http://dec.alaska.gov/commish/dec-history htm; ALASKA STAT. ANN. § 46.03.010(a).

"manage the basic resources of water, land, and air to the end that the state may fulfill its responsibility as trustee of the environment for the present and future generations."[30]

The Department has "primary responsibility for the adoption and enforcement of regulations setting standards for the prevention and abatement of all water, land, subsurface land, and air pollution, and other sources or potential sources of pollution of the environment, including by way of example only, petroleum and natural gas pipelines."[31] The legislature has similarly tasked the Department with "primary responsibility for coordination and development of policies, programs, and planning related to the environment of the state and the various regions of the state."[32] The Department must "take actions necessary and proper to further" the conservation, public health, and public trust purposes for which it was formed[33] by utilizing its authority to issue regulations providing for "control, prevention, and abatement of air, water, or land or subsurface land pollution."[34] In fulfilling the mandate of these provisions, the Department: makes recommendations to the Alaska Legislature; issues licenses and permits; initiates enforcement actions; serves as the primary link to the federal government on environmental issues; establishes ambient air quality standards, emission standards, and other regulatory standards; formulates and revises a statewide environmental plan; and works with the public, other state agencies, and legislators to implement environmental laws.[35] The Department is responsible for issuing regulations to carry out its mandates.[36]

Importantly, the Department has significant control over and responsibility for Alaska's GHG emissions due to the agency's affirmative acts of permitting and licensing facilities and activities that emit or result in GHG emissions. For example, the Department issues regulations, permits, and licenses for internal combustion engines, fossil fuel burning facilities and equipment (including power plants), asphalt plants, coal-fired plants, and other stationary and area sources, all of which emit GHGs.[37]

V. LEGAL FRAMEWORK: THE PUBLIC TRUST DOCTRINE, ALASKA CONSITUTION, AND ALASKA STATUTES & REGULATIONS: THE DEPARTMENT HAS THE AUTHORITY AND OBLIGATION TO ADDRESS CLIMATE CHANGE

A. The State of Alaska Has an Obligation Pursuant to the Public Trust Doctrine to Protect Alaska's Public Trust Resources for Present and Future Beneficiaries

The State of Alaska, including the Department of Environmental Conservation, has an obligation pursuant to the Public Trust Doctrine to manage and protect its natural resources for

[30] ALASKA STAT. ANN. § 46.03.010(b).
[31] ALASKA STAT. ANN. § 44.46.020(a)(2).
[32] ALASKA STAT. ANN. § 44.46.020(a)(1).
[33] ALASKA STAT. ANN. § 44.46.020(a)(4).
[34] ALASKA STAT. ANN. § 46.03.020(10).
[35] *See Handbook on Alaska State Government*, STATE OF ALASKA LEGISLATIVE AFFAIRS AGENCY 36-69, http://w3.legis.state.ak.us/docs/pdf/handbook.pdf; *see also* ALASKA STAT. ANN. §§ 46.03.020, 46.03.040, 46.14.010, 46.14.140, 46.14.510; 18 AAC §§ 50.005 et seq.; 52.005 et seq., 53.005 et seq.
[36] *See* ALASKA STAT. ANN. §§ 46.03.020(10), 44.46.020(a)(2), 46.14.010, 46.14.140, 46.14.510 (West 2016).
[37] *See* ALASKA STAT. ANN. Title 46, Chapter 46, Subchapter 14.

current and future Alaskans. The idea that essential natural resources are the collective property of humanity was first documented almost 1500 years ago in Roman law. The text of the *Institutes of Justinian* declared that, "By the laws of nature, these things are common to mankind—the air, running water, the sea, and consequently the shores of the sea."[38] This ancient pronouncement evidences the foundational aspect of the Public Trust Doctrine: the fundamental governmental principle that the sovereign (*i.e.*, the state) holds shared resources—the *jus publicum*—in trust for present and future generations.[39] A 1965 White House report articulated the public trust doctrine and stated: "The land, water, air and living things of the United States are a heritage of the whole nation. They need to be protected for the benefit of all Americans, both now and in the future." Trustees have an obligation that they cannot abdicate[40] to preserve and maintain trust assets for both present and future beneficiaries of the trust and to prevent the substantial impairment of trust resources.[41]

State constitutions through the United States, including Alaska's constitution, enshrine the Public Trust Doctrine in constitutional provisions. In *PPL Montana, LLC v. Montana,* the United States Supreme Court recognized that the Public Trust Doctrine "is of ancient origin" dating back to Roman civil law; that the Public Trust Doctrine is reflected in state laws and constitutional provisions throughout our nation; and that federalist principles of our nation affirm the state's rights and duties over public trust resources within their borders.[42] The universal constitutional application of the Public Trust Doctrine is evident in that citizens' rights to essential natural resources reflect "'inherent and independent rights' of mankind relative to the environment."[43] The architects of Alaska's Constitution recognized these fundamental rights, and enshrined the Public Trust Doctrine in numerous provisions of the state's foundational legal document.[44] However, because the Public Trust Doctrine is an inherent attribute of sovereignty[45]

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[38] Justinian, Institutes, 1.2.1, 2.1.1 (T. Sandars trans. 1st Am. ed. n. 1876). The *Institutes of Justinian* is one of three fundamental works of jurisprudence issued from 533 to 534 AD by order of the Eastern Roman Emperor Justinian I. Collectively, the works were intended to be the sole source of Roman law. Roman law provides the foundation for our own Western legal tradition. *See* John W. Head, *Codes, Cultures, Chaos, And Champions: Common Features of Legal Codification Experiences in China, Europe, and North America*, 13 DUKE J. COMP. & INT'L L. 1, 39 (2003).

[39] *See, e.g.*, *Baxley v. State*, 958 P.2d 434 (public trust doctrine "provides that the State holds certain resources (such as wildlife, minerals, and water rights) in trust for public use, 'and that the government owes a fiduciary duty to manage such resources for the common good of the public as beneficiary.'" (quoting *McDowell v. State*, 785 P.2d 1, 16 n.9 (Alaska 1989)).

[40] *Illinois Central R.R. Co. v. Illinois*, 146 U.S. 387, 453 (1892) ("The state can no more abdicate its trust over property in which the whole people are interested . . . than it can abdicate its police powers in the administration of government and the preservation of the peace.").

[41] Mary C. Wood, *Atmospheric Trust Litigation Across the World*, *in* FIDUCIARY DUTY AND THE ATMOSPHERIC TRUST 106, 109 n. 59 (Ken Coghill, Charles Sampford & Tim Smith, eds., 2012) (internal citations omitted) (available at https://law.uoregon.edu/images/uploads/entries/ATL-Across-the-World.pdf).

[42] *PPL Montana, LLC v. Montana*, 132 S. Ct. 1215, 1235–36 (2012).

[43] *Robinson Twp. v. Commonwealth*, 83 A.3d 901, 947 (Pa. 2013) (plurality opinion).

[44] A Citizen's Guide, *supra* note 9, at 129 ("Thus, the convention delegates sought to enshrine in the state constitution the principle that the resources of Alaska must be managed for the long-run benefit of the people as a whole – that is, the resources of the state must be managed as a public trust.").

[45] *Illinois Central R.R. Co.*, 146 U.S. at 455–56 ("[T]he decisions are numerous which declare that such property is held by the state, by virtue of its sovereignty, in trust for the public."); *Juliana*, 217 F.Supp.3d at 1260 ("The public trust doctrine defines inherent aspects of sovereignty.").

predating "all governments and constitutions,"[46] its obligations and the rights it affords citizens need not be explicitly mentioned in text to be of constitutional force.[47] That Alaska's constitutional delegates chose to expressly include Public Trust provisions emphasizes the importance of the Public Trust Doctrine to the state of Alaska and its citizen beneficiaries.

The Alaska Supreme Court recognized the Public Trust Doctrine in a 1988 case in which it was called upon to determine whether a state conveyance of tideland was subject to the public's continuing easement for purposes of navigation, commerce, and fishing.[48] In determining whether the conveyance passed free of any Public Trust obligations, the Court first had to determine "whether the conveyance was made in furtherance of some specific trust purpose and second, whether the conveyance can be made without substantial impairment of the public's interest in the state tidelands."[49] Later that same year, the Supreme Court addressed whether granting hunting guides exclusive guide areas violated the common use clause set forth in Article VIII, Section 3 of the Alaska Constitution.[50] Examining the history of the clause, the Court stated that the framers intended "to guarantee broad public access to natural resources."[51] The Court relied upon historic principles concerning a sovereign's management of water and wildlife resources, and found that the framers achieved their purpose by "constitutionalizing common law principles imposing upon the state a public trust duty with regard to the management of fish, wildlife and water...for the benefit of all the people."[52] Indeed, the framers of Alaska's Constitution intended that *all* "the resources of Alaska must be managed in the long-run for the benefit of the people as a whole – that is, the resources of the state must be managed as a public trust."[53] In *Baxley v. State*, the Alaska Supreme Court directly addressed the nature and purpose of the Public Trust Doctrine, explaining that the Public Trust Doctrine "provides that the State holds certain resources (such as wildlife, minerals, and water rights) in trust for public use, 'and that the government owes a fiduciary duty to manage such resources for the common good of the public as beneficiary.'"[54] Most recently, the Alaska Supreme Court indicated, while discussing the Public Trust Doctrine, that "the State acts as trustee with regard to the air just as it does with regard to other natural resources."[55]

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[46] *Oposa v. Factoran*, G.R. No. 101083 (S.C. July 30, 1993) (Phil.).

[47] *See id.* ("[T]hese basic rights need not even be written in the Constitution for they are assumed to exist from the inception of humankind."); *Juliana*, 217 F.Supp.3d at 1260 ("[P]ublic trust rights both predated the Constitution and are secured by it."); *Robinson Twp. v. Commonwealth*, 83 A.3d at 947–48 (Rights and duties provided under the Public Trust Doctrine "are inherent in man's nature and preserved rather than created by the Pennsylvania Constitution."); *See also*, Mehta v. Nath, (1996) 10 Suppl. S.C.R. 12 (India) (Declaring the basis of the public trust doctrine as laying in natural law and stating that "the laws of nature…are imposed by us by the natural world" and must "inform all our social institutions.").

[48] *CWS Fisheries, Inc. v. Bunker*, 755 P.2d 1115, 1118 (Alaska 1988).

[49] *Id*. at 1119

[50] *See Owsichek v. State*, 763 P.2d at 488 (Alaska 1988).

[51] *Id.* at 493.

[52] *Id*. at 493, 495.

[53] Harrison, A Citizen's Guide, *supra* note 9, at 129.

[54] 958 P.2d at 434 (quoting *McDowell v. State*, 785 P.2d 1, 16 n.9 (Alaska 1989)).

[55] *Kanuk ex rel. Kanuk v. State*, 335 P.3d at 1102 (Alaska Supreme Court noted that the "Alaska Legislature has already intimated that the State acts as trustee with regard to the air just as it does with regard to other natural resources;" and in n. 78, the Court further noted that the "legislature declared in AS 46.03.010(b) that it is "the policy of the state . . . to develop and manage the basic resources of water, land, *and air* to the end that the state may

The State of Alaska has an affirmative and mandatory duty under the Public Trust Doctrine to prevent, and to refrain from contributing to, substantial impairment to the State's essential natural resources, including the atmosphere (air), oceans, beaches, freshwaters of the State, fish, wildlife, and forests – each of which are seriously impacted by climate change. [56] The public's right to essential natural resources reflects their inherent rights that are preserved by the state[57] and federal constitutions.[58] As the Pennsylvania Supreme Court ruled in *Robinson Township*, the Public Trust Doctrine requires governments to "conserve and maintain" natural resources, and imposes the duty "to refrain from permitting or encouraging the degradation, diminution, or depletion of public natural resources, whether such degradation, diminution, or depletion would occur through direct state action or indirectly, *e.g.*, because of the state's failure to restrain the actions of private parties."[59] Governments also have the duty "to act affirmatively to protect the environment" via legislative or regulatory action.[60]

Recognizing that "[i]t is the policy of the state to…manage the basic resources of water, land, and air to the end that the state may fulfill its responsibility as trustee of the environment for the present and future generations,"[61] the Alaska Legislature codified the state's role as trustee of atmospheric resources under the Public Trust Doctrine and created the Department of Environmental Conservation to fulfill its Public Trust duty to protect trust resources for present and future generations.[62] The Department must now fully implement both the letter and the spirit of the laws in such a manner as to do its part to protect Alaska citizens from catastrophic climate change. As a Washington State court recently stated: "[F]ederal mechanisms designed to protect the environment are now under siege, more than ever leaving to the States the obligation to protect their citizens under the Public Trust Doctrine."[63] If the Department, as trustee of the atmosphere, does not take immediate and extraordinary action to do its part in connection with a global effort to protect, preserve, and bring the Earth's atmosphere back into balance, then children in Alaska, Alaska Natives, and countless future generations of children will suffer continually greater injuries and damaging consequences. Failure to act in these circumstances

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fulfill *its responsibility as trustee of the environment for the present and future generations*.") (Emphasis in original).

[56] *Id.; See also Geer v. Connecticut*, 161 U.S. 519, 534 (1896) ("[I]t is the duty of the [state] to enact such laws as will best preserve the subject of the trust and secure its beneficial use in the future to the people of the State."), *partially overruled on other grounds by Hughes v. Oklahoma*, 441 U.S. 322 (1979); *City of Milwaukee v. State*, 214 N.W. 820, 830 (Wis. 1927) ("The trust reposed in the state is not a passive trust; it is governmental, active, and administrative...[and] requires the lawmaking body to act in all cases where action is necessary, not only to preserve the trust, but to promote it."); *Juliana v. United States*, 217 F.Supp.3d 1224, 1254 (D. Or. 2016) ("The government, as trustee, has a fiduciary duty to protect the trust assets from damage so that current and future trust beneficiaries will be able to enjoy the benefits of the trust.").

[57] *See* ALASKA CONST., Preamble, Art. I §§ 1, 7, Art. VIII.

[58] *See Juliana*, 217 F.Supp.3d at 1261 ("Public Trust claims rest "directly on the Due Process Clause of the Fifth Amendment.") (citations and quotations omitted).

[59] 83 A.3d at 957.

[60] *Id*. at 958.

[61] ALASKA STAT. ANN. § 46.03.010(b).

[62] *Id.*; *see also* ALASKA STAT. ANN. § 46.03.010(a).

[63] *Foster v. Wash. Dep't of Ecology*, No. 14-2-25295-1, slip. op. at 4 (Wash. King Cty. Super. Ct., April 18, 2017), https://static1.squarespace.com/static/571d109b04426270152febe0/t/59a0b19e03596e3462c19d63/1503703455307/2017.04.18+Order+Granting+Motion+to+Amend.pdf.

constitutes a breach of the state's fiduciary duty to protect the atmospheric trust asset for the benefit of current and future Alaskans.

The public trust imposes a legal obligation on the Department to affirmatively preserve and protect the citizens' trust assets from damage or loss, and not to use, waste or dispose of the asset in a manner that causes injury to the trust beneficiaries, be they present or future. Alaska's fiduciary duty in this instance is defined by scientists' concrete prescriptions for CO_2 reductions. The current level of CO_2 in the atmosphere, over 400 ppm, constitutes substantial impairment of the atmosphere, the ocean, and the climate system.[64] Additionally, this level of CO_2 in the atmosphere is causing the substantial impairment of other trust resources including Alaska's coastal waters and marine life, Alaska's freshwaters and permafrost, as well as Alaska's fish, wildlife, and forests.[65] Scientists have clearly expressed the minimum CO_2 reductions that are needed and requisite timelines for their implementation.[66] Alaska may not disclaim this fiduciary obligation, and is subject to an ongoing mandatory duty to preserve and protect the atmosphere and other trust assets.

B. The Department has a Constitutional Obligation to Protect Alaskans' Inherent and Inalienable Rights and Common Welfare

Article I, Section 1 of the Alaska Constitution, titled *Inherent Rights*, recognizes that "all persons have a natural right to life, liberty, the pursuit of happiness, and the enjoyment of the rewards of their own industry; [and] that all persons are equal and entitled to equal rights, opportunities, and protection under the law."[67] "No person shall be deprived" of such inherent rights "without due process of law."[68] By enumerating these inherent rights, the framers of the Alaska Constitution clarified their purpose to transmit and protect liberty and Alaska's heritage to "succeeding generations."[69] Article VIII, Section 2 states: "The legislature shall provide for the utilization, development, and conservation of all natural resources belonging to the State, including land and waters, for the maximum benefit of its people."[70] Article VIII, Section 1 likewise calls for resource development that is "consistent with the public interest,"[71] meaning that "the principles of conservation must govern resource management…[and] that everyone should be treated equally by [natural resource] management rules…."[72] Section 4 of Article VIII also mandates that *all* "replenishable resources belonging to the State shall be utilized,

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[64] Dec. of Dr. Ove Hoegh-Guldberg In Support of *Foster v. Wash. Dep't of Ecology*, No. 14-2-25295-1 SEA, at 1,(Wash Sup. Ct. Aug. 24, 2015), https://static1.squarespace.com/static/571d109b04426270152febe0/t/59a0e23dd482e9c868986767/1503715905156/15.08.25+Hoegh-GuldbergDecl.pdf; *Foster v. Wash. Dep't of Ecology*, No. 14-2-25295-1 SEA, 2015 WL 7721362, 8 (Wash. Super. Ct. Nov. 19, 2015), https://static1.squarespace.com/static/571d109b04426270152febe0/t/57607fe459827eb8741a852c/1465941993492/15.11.19.Order_FosterV.Ecology.pdf.; Hansen 2016 Declaration, *supra* note 15

[65] *See Infra* § F2.

[66] *See, e.g.,* Hansen 2016 Declaration, *supra* note 15

[67] ALASKA CONST. art. I, § 1.

[68] ALASKA CONST. art. I, § 7.

[69] ALASKA CONST., preamble.

[70] ALASKA CONST. art. VIII, § 2.

[71] ALASKA CONST. art. VIII, § 1.

[72] Harrison, A Citizen's Guide, *supra* note 9, at 131.

developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses."[73] Further, as Professor Gordon S. Harrison explains, Article VIII of Alaska's Constitution expressly recognizes the state's Public Trust Obligations: "Thus, the convention delegates sought to enshrine in the state constitution the principle that the resources of Alaska must be managed for the long-run benefit of the people as a whole – that is, the resources of the state must be managed as a public trust."[74]

There is no natural resource of more importance to the public, and succeeding generations, or more reliant on sustainable practices, than a healthy atmosphere and stable climate system. A healthy atmosphere and stable climate system are required in order to enjoy and defend life, liberty, property, safety, happiness, and all other fundamental and inherent rights. The Alaska Constitution expressly recognizes the fundamental principle that governments are founded by the people for the benefit of the people.[75] The most central and basic benefit that a government can provide is to protect those essential natural resources necessary for its people to survive and thrive and for society to function, evolve, and reproduce for future generations. As the District Court of Oregon recently declared in *Juliana v. United States* – a federal, youth-led, constitutional and Public Trust case– inherent rights to life, liberty, and property rest upon the foundational, and likewise inherent right to "a climate system capable of sustaining human life" – a right that is "fundamental to a free and ordered society."[76] As the *Juliana* court stated: "Just as marriage is the 'foundation of the family,' a stable climate system is quite literally the foundation 'of society, without which there would be neither civilization nor progress.'"[77] In another youth-led climate case, a Washington state court captured the urgent need of protecting these inherent rights, stating: "[i]f ever there were a time to recognize through action this right to preservation of a healthful and pleasant atmosphere, the time is now . . . ."[78] That court also noted that the youth petitioners "very survival depends upon the will of their elders to act now, decisively and unequivocally, to stem the tide of global warming by accelerating the reduction of emission of GHG's . . . ."[79]

Constitutionally, the State of Alaska has a "fundamental governmental duty to ensure public safety and welfare."[80] Contrary to that duty, and in contravention to Petitioners' due process rights, the state's actions in licensing and permitting GHG emissions-producing facilities and activities, and the state's direct participation in GHG emissions-producing activities, contributes to climate change and ocean acidification, affirmatively harming Alaska's citizens. Likewise, the state's failure to adequately respond to the threat of climate change threatens

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[73] ALASKA CONST. art. VIII, § 4.
[74] Harrison, A Citizen's Guide, *supra* note 9, at 129.
[75] ALASKA CONST. art. I, § 2 ("All political power is inherent in the people. All government originates with the people, is founded upon their will only, and is instituted solely for the good of the people as a whole.").
[76] *Juliana*, 217 F.Supp.3d at 1250.
[77] *Id.* (quoting *Obergefell v. Hodges*, 135 S. Ct. 2584, 2598 (2015) (quoting *Maynard v. Hill*, 125 U.S. 190, 211 (1888))).
[78] *Foster v. Wash. Dep't of Ecology*, No. 14-2-25295-1 SEA, 2015 WL 7721362, slip. op at 9 (Wash. Super. Ct. Nov. 19, 2015), https://static1.squarespace.com/static/571d109b04426270152febe0/t/57607fe459827eb8741a852c/1465941993492/15.11.19.Order_FosterV.Ecology.pdf
[79] *Id.* at 5.
[80] *Myers v. Alaska Housing Finance Corp.*, 68 P.3d 386, 401 (Alaska 2003).

public safety and welfare. For instance, an increasingly destabilized climate system brings more frequent and intense storms; temperature extremes; wildfires; severe coastal erosion and sea level rise; the loss of frozen tundra and permafrost on which many Alaska Native communities depend; the spread of pests, diseases, and allergens; and ocean acidification, among other impacts. Further, these actions and omissions unconstitutionally favor the short-term economic benefit of current generations at the expense of the youths' fundamental rights, discriminating against them in violation of Alaska's constitutional guarantee that "all persons are equal and entitled to equal rights, opportunities, and protection under the law."[81]

The United States Constitution also informs the scope of Petitioners' individual fundamental rights and the Department's obligations with respect thereto. Under the terms of the 14th Amendment to the U.S. Constitution, a state may not deprive its citizens of life, liberty, or property, without due process of law, nor deny them equal protection of the laws.[82] These rights belong to present generations as well as to future generations (our "Posterity").[83] These inherent and inalienable rights reflect the basic societal contract of the U.S. Constitution to protect citizens and posterity from government infringement upon basic freedoms and basic (or natural) rights.

Our nation's climate system, including the atmosphere and oceans, is critical to Petitioners' rights to life, liberty, and property, yet the nation's climate system has been, and continues to be, harmed by dangerous levels of greenhouse gas emissions. Furthermore, youth petitioners will be denied their constitutional rights to equal protection of the laws because they will disproportionately experience the irreversible and catastrophic impacts of an atmosphere and oceans containing dangerous levels of CO_2 and a dangerous destabilized national climate system. Today's adults will not experience the full scope of catastrophic harms that will be experienced by Youth Petitioners . In order to ensure that the U.S. and Alaskan Constitutional rights of Petitioners, and all Alaskans, to life, liberty, and property, and equal protection of the laws, are not further infringed upon, Alaska must do its part to ensure that a balanced climate system is restored, and CO_2 levels are reduced to no more than 350 ppm.

Of course, rights guaranteed under U.S. Constitution as presently interpreted by the U.S. Supreme Court represent a floor, not a ceiling to the rights established by the states. Alaskans have long benefited from a broader array of protection under the Alaska Constitution.[84] Even when Alaska Constitutional provisions are closely akin to those of the Federal Constitution, the state has "*a duty*, to develop additional constitutional rights and privileges" fundamental to the "intention and spirit of [Alaska's] constitutional language and…necessary for the kind of

[81] ALASKA CONST. art. I, § I.
[82] U.S. CONST. amend. XIV, § 1.
[83] U.S. CONST. preamble (The framers established the constitution in order to "secure the Blessings of Liberty to ourselves and our Posterity….").
[84] *See, e.g., Ravin v. State*, 537 P.2d 494, 513 (Alaska 1975) (J. Boochever, concurring); *Malabed v. North Slope Borough*, 70 P.3d 416, 420 (Alaska 2003) ("We have long recognized that the Alaska Constitution's equal protection clause affords greater protection to individual rights than the United States Constitution's Fourteenth Amendment."); *Alaska Civil Liberties Union v. State*, 122 P.3d 781, 785 (Alaska 2005) ("Article I, section 1 of the Alaska Constitution "mandates 'equal treatment of those similarly situated;' it protects Alaskans' right to non-discriminatory treatment more robustly than does the federal equal protection clause.").

civilized life and ordered liberty which is at the core of our constitutional heritage."[85] Rather than "stand by idly and passively, waiting for constitutional direction from the highest court of the land," Alaska prides itself on "moving concurrently to develop and expound the principles embedded in [its] constitutional law."[86]

Alaska, through its "equal protection clause," has done just that: it has guaranteed youth Petitioners "not only equal 'protection,' but also equal 'rights' and 'opportunities' under the law."[87] The impacts of climate change described below (see Section VI below) threaten the constitutional rights of all Alaskans, but especially those of Petitioners , who, as a result of current and future impacts of climate change, are not now – or in the future – able to enjoy *rights* and *opportunities* equal to those enjoyed by the rest of us. Indeed, without immediate science-based actions to reduce CO_2 emissions, the impacts of climate change and ocean acidification will lead to a very different, far less hospitable planet.

C. The Department is Statutorily Obligated to Protect Alaska's Public Trust Resources by Regulating Greenhouse Gas Emissions

The essential purpose of the Alaska Department of Environmental Conservation is to protect Alaska's natural resources for the public's benefit. Specifically, the Alaska legislature formed the Department for the purposes set forth in the Department's organic statute. That statute makes clear that the Department's reason for being is to: (1) "*conserve, improve, and protect* [Alaska's] *natural resources* and environment and control water, land, and air pollution, in order *to enhance the health, safety, and welfare of the people of the state* and their overall economic and social well-being;" and (2) "manage the basic resources of water land, and air to the end that the state may *fulfill its responsibility as trustee for the present and future generations*."[88] To these ends, the Alaska Legislature has tasked the Department with the authority and obligation to both "adopt regulations necessary to carry out" and "take actions necessary and proper to further" such purposes[89] and designated the Department as the governmental entity with "primary responsibility for the adoption and enforcement of regulations setting standards for the prevention and abatement of all water, land, subsurface land, and air pollution, and other sources or potential sources of pollution of the environment…."[90]

In addition to the Department's general authority and mandate to issue and enforce regulations for the protection and conservation of Alaska's natural resources, including the atmosphere,[91] the Alaska Legislature specifically authorized the Department to adopt regulations "establishing ambient air quality standards [and] emissions standards,"[92] and "for the control of

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[85] *Ravin*, 537 P.2d at 513 (J. Boochever, concurring).
[86] *Id*.
[87] *Alaska Civil Liberties Union*, 122 P.3d at 785.
[88] ALASKA STAT. ANN. § 46.03.010 (emphasis added).
[89] ALASKA STAT. ANN. §§ 46.03.020(10), 46.46.020(a)(4).
[90] ALASKA STAT. ANN. § 44.46.020(a)(2); *See also* ALASKA STAT. ANN. § 44.46.020(a)(1) (The Department has "primary responsibility for coordination and development of policies, programs, and planning related to the environment of the state and of the various regions of the state.").
[91] ALASKA STAT. ANN. §§ 46.03.020(10), 44.46.020(a)(2), 46.46.020(a)(4).
[92] ALASKA STAT. ANN. § 46.14.010(a).

the emissions from motor vehicles,"[93] and directed the Department to "adopt regulations to address substantive and procedural elements of the emission control permit program…."[94]

Per the Air Quality and Control Chapter of Alaska's Administrative Code, the Department has a duty "to identify, prevent, abate, and control air pollution in a manner that meets the purposes of AS 46.03, AS 46.14, and [the federal Clean Air Act]...."[95] The purposes of AS 46.03, as pertaining to the regulation of air pollution, including greenhouse gas emissions ("GHGs"), are: (1) "to conserve, improve, and protect [Alaska's] natural resources and environment and control...*air pollution, in order to enhance the health, safety, and welfare of the people of the state* and their overall economic and social well-being;"[96] and (2) "to improve and coordinate the environmental plans, functions, powers, and programs of the state, in cooperation with the federal government, regions, local governments, other public and private organizations, and concerned individuals, and to develop and *manage the basic resource[] of...air to the end that the state may fulfill its responsibility as trustee of the environment for the present and future generations*."[97] AS 46.14 specifically authorizes the Department to set ambient air quality and emissions standards and regulate motor vehicle emissions, and directs the Department to regulate the control emission permit program.[98]

Both the Department's organic statute and the Air Quality and Control Chapter of Alaska's Administrative Code, adopted pursuant thereto, define "air pollution" as "the presence in the outdoor atmosphere of one or more air contaminants in quantities and duration that *tend to be injurious to human health or welfare, animal or plant life or property or would unreasonably interfere with the enjoyment of life or property*."[99] As demonstrated in Section VI below , elevated levels of greenhouse gases in the atmosphere are injurious to human, plant and animal life, and to property, such that the Department is statutorily obligated to regulate Alaska's GHG emissions. Additionally, Alaska's definition is consistent with the definition of "air pollutant" contained in the federal Clean Air Act.[100] In *Massachusetts v. EPA*, the U.S. Supreme Court declared that CO_2 is an air pollutant covered by the Clean Air Act[101] and the Department already has adopted federal standards governing GHG emissions from a number of sources.[102]

VI. FACTUAL BACKGROUND – CLIMATE CHANGE AND ALASKA

[93] ALASKA STAT. ANN. § 46.14.510(a).
[94] ALASKA STAT. ANN. § 46.14.140(a).
[95] 18 AAC § 50.005.
[96] ALASKA STAT. ANN. 46.03.010(a).
[97] ALASKA STAT. ANN. 46.03.010(b).
[98] ALASKA STAT. ANN. §§ 46.14.010(a), 46.14.510(a), 46.14.140(a).
[99] ALASKA STAT. ANN. § 46.03.900(2); 18 AAC § 50.990(5).
[100] *See* 42 U.S.C.A. § 7602(g) ("The term 'air pollutant' means any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material) substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the Administrator has identified such precursor or precursors for the particular purpose for which the term 'air pollutant' is used.").
[101] 549 U.S. 497, 534–35 (2007).
[102] *See, e.g.*, 18 AAC § 50.040(a)(2)(XX), (YY).

Alaska's efforts to reduce GHG emissions have thus far been insufficient to adequately protect the interests of current and future citizens of Alaska. Numerous climate change studies have been commissioned and completed, but this is not sufficient to address Alaska's climate crisis. In order to avoid catastrophic climate change, the State's efforts need to be guided by a scientifically-prescribed goal of reducing GHG emissions sufficient for Alaska to do its part to return the atmospheric concentration of CO_2 to 350 ppm by 2100.

In its final 2007 report to the Alaska Legislature, the Alaska Climate Impacts Assessment Commission explicitly recognized Alaska's need for the best, most up-to-date science when assessing climate change mitigation tactics: "The Commission concluded that informed decision-making will need *objective, reliable data,* continued monitoring activities in the field and at sea, and *the most up-to-date research we can acquire*. What follows is the best, most objective, reliable data and up-to-date research regarding the science of climate change, its impacts, and the proscription to end it. This information necessitates adoption of Petitioners' proposed rule.

A. The Science Unequivocally Shows that Anthropogenic Climate Change is Occurring, and is Threatening the Stability of the Global Climate System

1. Climate Change is Caused by Human Activities

For over fifty years, the United States government has known that carbon dioxide pollution from burning fossil fuels was causing global warming and dangerous climate change, and that continuing to burn fossil fuels would destabilize the climate system on which present and future generations of our nation depend for their wellbeing and survival.[103] In a 1965 Report of President Lyndon Johnson's Scientific Advisors, "Restoring the Quality of Our Environment," the President's Science Advisory Committee stated: "that "pollutants have altered on a global scale the carbon dioxide content of the air" through the "burning of coal, oil and natural gas."[104] The Executive Branch warned that "carbon dioxide [gases] are accumulating in such large quantities that they may eventually produce marked climatic change."[105] The 1965 Report confirmed that anthropogenic pollutants, including CO_2, threaten "the health, longevity, livelihood, recreation, cleanliness and happiness of citizens who have no direct stake in their production, but cannot escape their influence."[106] The Executive Branch described the marked climatic changes from CO_2 pollution as including the melting of the Antarctic icecap, rising sea levels, warming oceans, acidifying waters, and additional releasing of CO_2 and methane due to these events.[107] It recommended reducing the heating of the Earth because of the "extraordinary

[103] President's Science Advisory Committee, Environmental Pollution Panel, *Restoring the Quality of Our Environment* (1965) https://dge.carnegiescience.edu/labs/caldeiralab/Caldeira%20downloads/PSAC,%201965,%20Restoring%20the%20Quality%20of%20Our%20Environment.pdf; *see also* T. C. Chamberlin, *An Attempt to Frame a Working Hypothesis of the Cause of Glacial Periods on an Atmospheric Basis*, J. GEOLOGY 7, 575 (1899) (Scientists understood that CO_2 concentrations in the atmosphere cause heat retention on Earth and that a doubling or tripling of the CO_2 content in 1899 would significantly elevate Earth's surface temperature.).
[104] *Restoring the Quality of Our Environment*, *supra* note 103, at 1, 9.
[105] *Id.* at 12
[106] *Id* at 1.
[107] *Id* at 123–24.

economic and human importance" of our climate system.[108] Since 1965, studies and reports also have made clear the significant harms that would be caused if we did not and do not reduce reliance on carbon-intense energy from fossil fuels and rapidly transition to carbon-free energy.[109]

Since 1990, the best available science has shown that CO_2 levels in the atmosphere must be stabilized at or below 350 ppm in order to protect our nation's climate system and that a swift transition away from fossil fuels was necessary.[110] In December 1990, the U.S. Environmental Protection Agency ("EPA") submitted a report to Congress on "Policy Options for Stabilizing Global Climate."[111] The EPA's 1990 Report concluded: "responses to the greenhouse problem that are undertaken now will be felt for decades in the future, and lack of action now will similarly bequeath climate change to future generations."[112] The 1990 Report called for stabilizing atmospheric CO_2 concentrations at 350 ppm, the current level of that time. In its 1990 Report, EPA confirmed the Executive Branch's findings from 1965 that CO_2 was a "dangerous" pollutant. Twenty-five years later, today's best science confirms that 350 ppm is the maximum safe level of atmospheric CO_2 required to restore a stable climate system.

On October 15, 1992, the Senate ratified the United Nations Framework Convention on Climate Change ("UNFCCC").[113] The UNFCCC was executed to "protect the climate system for the benefit of present and future generations of humankind."[114] The UNFCCC evidences an "overwhelming weight" of support for protection of the atmosphere under the norms and principles of intergenerational equity.[115] The minimal objective of the UNFCCC is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."[116]

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[108] *Id.* at 127.
[109] Intergovernmental Panel on Climate Change ("IPCC"), *IPCC Fifth Assessment Report: Climate Change 2013*, 1.1, 123 (2013), http://www.ipcc.ch/report/ar5/wg1, [Hereinafter *AR5*]; James Hansen et. al., *Young People's Burden: Requirement of Negative CO_2 Emissions* 8 EARTH SYSTEM DYNAMICS 577, July 18, 2017) [Hereinafter *Young People's Burden*] https://arxiv.org/pdf/1609.05878.pdf.
[110] EPA, *Policy Option for Stabilizing Global Climate: Report to Congress* 1, 8, I-5, IV-19 (1990), https://books.google.com/books?id=_YkTAAAAYAAJ&printsec=frontcover#v=onepage&q&f=false (last visited April 27, 2017).
[111] *Id.*
[112] *Id.* at III-15.
[113] UNFCCC, *Status of Ratification of the Convention*, http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php.
[114] UNFCC, *First Steps to a Safer Future: Introducing the United Nations Framework Convention on Climate Change*, http://unfccc.int/essential_background/convention/items/6036.php.
[115] UNFCCC, Art. 3, http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf.
[116] UNFCCC, Art. 2, http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf.

The United States Global Change Research Program ("USGCRP")[117] has confirmed that anthropogenic global warming is occurring and is adversely impacting the Earth's climate.[118] The present rate of global heating is occurring as a result of human activities that release heat-trapping GHGs and intensify the Earth's natural greenhouse effect at an accelerated rate, thereby changing Earth's climate.[119] This abnormal climate change is unequivocally human-induced,[120] is occurring now, and will continue to occur unless drastic measures are taken to curtail it.[121] Climate change is damaging both natural and human systems, and if unrestrained, will alter the planet's habitability.[122]

According to the United States Environmental Protection Agency ("EPA"), "the case for finding that *greenhouse gases in the atmosphere endanger public health and welfare is compelling and, indeed, overwhelming*."[123] The EPA further stated in April 2009 that "the evidence points ineluctably to the conclusion that climate change is upon us as a result of greenhouse gas emissions, that *climate changes are already occurring that harm our health and welfare, and that the effects will only worsen over time in the absence of regulatory action*."[124]

Human beings have benefited from living on a hospitable planet with conditions that are just right for human life to evolve, expand, and flourish.[125] The Earth is a "Goldilocks" planet

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[117] "The U.S. Global Change Research Program ("USGCRP") was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act ("GCRA") of 1990 to "assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change." The organization's vision is to produce "[a] nation, globally engaged and guided by science, meeting the challenges of climate and global change." Their mission is "to build a knowledge base that informs human responses to climate and global change through coordinated and integrated Federal programs of research, education, communication, and decision support." *About*, GLOBALCHANGE.GOV, http://www.globalchange.gov/about (last accessed Aug. 13, 2017).

[118] USGCRP, *Climate Change Impacts in the United States*: *Third National Climate Assessment*, 7 (2014) [hereinafter *Climate Change Impacts*], http://nca2014.globalchange.gov/downloads ("Evidence for climate change abounds, from the top of the atmosphere to the depths of the oceans . . . . Evidence of climate change is also visible in the observed and measured changes in location and behavior of species and functioning of ecosystems. Taken together, this evidence tells an unambiguous story: the planet is warming, and over the last half century, this warming has been driven primarily by human activity.").

[119] *Id.* ("Multiple lines of independent evidence confirm that human activities are the primary cause of the global warming of the past 50 years."); Deutsche Bank Climate Change Advisors, *Climate Change: Addressing the Major Skeptic Arguments* 9 (2010), https://www.uea.ac.uk/documents/3154295/7847337/Deutsche-Bank-CRU-report.pdf; *AR5*, *supra* note 109, at 1.1, 123.

[120] USGCRP, *Climate Change Impacts*, *supra* note 118, at 7.

[121] *Id.* at 14 ("The cumulative weight of the scientific evidence contained in this report confirms that climate change is affecting the American people now, and that choices we make will affect our future and that of future generations."); IPCC, *AR5*, *supra* note 109, at 1.2.2, 124 (2013) ("Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.").

[122] USGCRP, *Climate Change Impacts*, *supra* note 118, at 5 ("While some climate changes will occur slowly and relatively gradually, others could be rapid and dramatic, leading to unexpected breaking points in natural and social systems.").

[123] U.S. Environmental Protection Agency, Proposed Endangerment Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 18886, 18904 (Apr. 24, 2009) (to be codified in 40 C.F.R. Chapter 1) [hereinafter *TS Endangerment Findings*] (emphasis added).

[124] *Id.* (emphasis added).

[125] John Abatzoglou et al., *A Primer on Global Climate Change and Its Likely Impacts*, *in* CLIMATE CHANGE: WHAT IT MEANS FOR US, OUR CHILDREN, AND OUR GRANDCHILDREN 11, 15–22 (Joseph F. C. DiMento & Pamela

with an atmosphere that has fewer GHGs than that of Venus (which is too hot), and more than that of Mars (which is too cold), which is just perfect for the amazing diversity of life that has developed and thrived on planet Earth.[126]

GHGs in the atmosphere act like a blanket over the Earth to trap the heat that it receives from the sun.[127] More GHGs in the atmosphere mean that more heat is being retained on Earth, with less heat radiating back out into space.[128] Without this greenhouse effect, the average surface temperature of our planet would be 0°F (- 18°C) instead of 59°F (15°C).[129] Scientists have understood this basic mechanism of global warming since the late-nineteenth century.[130]

Human beings have significantly altered the chemical composition of the Earth's atmosphere and its climate system.[131] Collectively, we have changed the atmosphere and the Earth's climate system by engaging in activities that produce or release GHGs into the atmosphere.[132] Carbon dioxide is the key GHG, and there is abundant evidence that its emissions are largely responsible for the current warming trend.[133] Although much of the excess carbon dioxide is absorbed by the oceans, plants, and forests, the increase of GHG concentrations resulting from historic and present human activities has altered the Earth's ability to maintain the delicate balance of energy it receives from the sun and that which it radiates back out into space.[134]

In 2013, the CO_2 concentration in our atmosphere exceeded 400 ppm for the first time in recorded history (compared to the pre-industrial concentration of 280 ppm).[135] For the first time since CO_2 levels in the global atmosphere have been tracked, the monthly global average

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Doughman eds., 2007) https://books.google.com/books?hl=en&lr=&id=PXJIqCkb7YIC&oi=fnd&pg=PA11&ots=m1PgvJeTRL&sig=zoVAvqQlsVEgWZSsWSNk7yIH3AE#v=onepage&q&f=false [hereinafter *A Primer on Global Climate Change*] ("The earth's climate system can be thought of as an elaborate balancing act of energy, water, and chemistry involving the atmosphere, oceans, ice masses, biosphere, and land surface.").

[126] JAMES HANSEN, STORMS OF MY GRANDCHILDREN 224–25 (2009); *See* Abatzoglou, *A Primer on Global Climate Change*, *supra* note 125, at 23.

[127] Abatzoglou, *A Primer on Global Climate Change*, *supra* note 125, at 22.

[128] *Id.* at 16–17.

[129] *Id.* at 17.

[130] *See id.* at 35 (describing the efforts of Swedish chemist Svante Arrhenius).

[131] Naomi Oreskes, *The Scientific Consensus on Climate Change*, *in* CLIMATE CHANGE: WHAT IT MEANS FOR US, OUR CHILDREN, AND OUR GRANDCHILDREN 65, 93 (Joseph F. C. DiMento & Pamela Doughman eds., 2007) http://www.project2061.org/events/meetings/climate2010/includes/media/NotwrongClimateChange.MITPress.2007.pdf ("We have changed the chemistry of our atmosphere, causing sea level to rise, ice to melt, and climate to change. There is no reason to think otherwise."); *see also* Wash. Exec. Order No. 14-04 (Apr. 29, 2014), http://www.governor.wa.gov/sites/default/files/exe_order/eo_14-04.pdf.

[132] *Id.*

[133] *See* James E. Hansen et al., *Target Atmospheric CO_2: Where Should Humanity Aim?* 2 OPEN ATMOSPHERIC SCI. J. 217, 217–31 (2008), http://www.columbia.edu/~jeh1/2008/TargetCO2_20080407.pdf [hereinafter *Where Should Humanity Aim?*].

[134] Abatzoglou, *A Primer on Global Climate Change*, *supra* note 125, at 15–22.

[135] NOAA, *Greenhouse Gases Continued Rising in 2013, 34 Percent Increase Since 1990*, NOAA (May 2, 2012), http://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/10553/Greenhouse-gases-continued-rising-in-2013-34-percent-increase-since-1990.aspx ("We continue to turn the dial up on this 'electric blanket' of ours without knowing what the resulting temperatures will be.").

concentration of CO_2 was 400 ppm for the entire month of March 2015.[136] On April 18, 2017, atmospheric concentrations of CO_2 exceeded 410 ppm for the first time in human history, and indeed, since long before humans began maintaining records of any sort.[137] Current atmospheric CO_2 concentrations are the highest they have been in the last 3 million years.[138] The rate of fossil fuels emissions has also increased from 1.5%/year during 1973-2000 to 2.6%/year in 2000-2014.[139] The rate of CO_2 concentrations' increase in the atmosphere is also increasing,[140] from 0.85 ppm per year in the 1960-1970 period, to 2.0 ppm per year in the 2000-2010 period.[141]

Concentrations of other GHGs in the atmosphere have also increased from human activities. Atmospheric concentrations of methane, for example, have increased nearly 250% since the pre-industrial period.[142] Concentrations of nitrous oxide have also increased by 120%.[143]

Humans not only continue to add GHGs into the atmosphere at a rate that outpaces their removal through natural processes,[144] but the current and projected CO_2 increase, for example, is about one hundred times faster than any that has occurred over the past 800,000 years.[145] This increase has to be considered in light of the lifetime of greenhouse gases in the atmosphere. A substantial portion (around 20%) of every ton of CO_2 emitted by humans persists in the atmosphere for as long as a millennium or more, and while there, it continues to affect the climate system.[146] The current concentrations of GHGs in the atmosphere, therefore, are the result of both historic and current emissions. As the bulk of current GHG emissions will persist

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[136] NOAA, *Greenhouse Gas Benchmark Reached* (May 6, 2015), http://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/11153/Greenhouse-gas-benchmark-reached-.aspx.

[137] Brian Kahn, *We Just Breached the 410 PPM Threshold for CO_2*, SCIENTIFIC AM. (April 21, 2017), https://www.scientificamerican.com/article/we-just-breached-the-410-ppm-threshold-for-co2.

[138] Hansen 2016 Declaration, *supra* note 15, at ¶ 16; Dieter Lüthi et al., *High-resolution Carbon Dioxide Concentration Record 650,000- 800,000 Years Before Present* 453 NATURE 379, 379–82 (May 2008), http://www.nature.com/nature/journal/v453/n7193/full/nature06949.html [hereinafter *High-resolution Carbon Dioxide Concentration Record*] (prior to this publication it was accepted atmospheric CO_2 record extended back 650,000 years, but now research indicates that the record can be extended 800,000 years, or two complete glacial cycles).

[139] Hansen, 2016 Declaration, *supra* note 15, at ¶ 19.

[140] Hansen, *Young People's Burden*, *supra* note 109.

[141] Hansen, 2016 Declaration, *supra* note 15, at ¶ 21.

[142] IPCC, *AR5*, *supra* note 109, at TS.2.8.3, 52 ("The concentration of CH_4 has increased by a factor of 2.5 since pre-industrial times, from 722 [697 to 747] ppb in 1750 to 1803 [1799 to 1807] ppb in 2011.").

[143] *Id.* at TS.2.8.4, 52.

[144] EPA, *TS Endangerment Findings*, *supra* note 123, at ES-2 ("Atmospheric GHG concentrations have been increasing because anthropogenic emissions have been outpacing the rate at which GHGs are removed from the atmosphere by natural processes over timescales of decades to centuries.").

[145] Lüthi, *High-resolution Carbon Dioxide Concentration Record*, *supra* note 138, at 379–82.

[146] Hansen, *Where Should Humanity Aim?*, *supra* note 133, at 220; *see also* EPA, *TS Endangerment Findings*, *supra* note 123, at 16 ("Carbon cycle models indicate that for a pulse of CO_2 emissions, given an equilibrium background, 50% of the atmospheric increase will disappear within 30 years, 30% within a few centuries, and the last 20% may remain in the atmosphere for thousands of years."); Abatzoglou, *A Primer on Global Climate Change*, *supra* note 125, at 29 ("Since CO_2 has a lifetime of over one hundred years, these emissions have been collecting for many years in the atmosphere.").

for centuries to millennia, the impacts associated with the GHG emissions of today will be mostly borne by our children and future generations.

Changes in different aspects of Earth's climate system over the last century tell a coherent story: the impacts we see today are consistent with the scientific understanding of how the climate system should respond to GHG increases from human activities and how the Earth has responded to increases in CO_2 in the past.[147] This is reflected in ice cores that have trapped air from thousands to a few million years ago, tree rings, and seabed sediments that show where sea level was thousands and even millions of years ago.[148] Collectively, these changes cannot be explained as the product of natural climate variability alone.[149] A substantial and predominant human contribution provides the best explanation of observed climate changes.[150]

These well-documented and observable impacts from the changes in Earth's climate system highlight that the current level of atmospheric CO_2 concentration has already taken the planet into a danger zone.[151] The Earth will continue to warm in reaction to concentrations of CO_2 from past emissions as well as present and future emissions.[152]

2. Global Temperature Increases

One key observable change is the rapid increase in recorded global surface temperatures.[153] As a result of increased atmospheric GHGs from human activities, the Earth has warmed as scientists have predicted.[154] The increased concentrations of greenhouse gases in our atmosphere, primarily CO_2,[155] have raised global surface temperature by 1.1°C (2°F) since the late nineteenth century,[156] which is close to, and probably slightly above, the maximum warming of the Holocene area, the period of relatively stable climate over the last 10,000 years over which human civilization developed.[157] In the last century, the Earth has warmed at a rate "roughly ten times faster than the average rate of ice-age-recovery warming."[158] Because of the centuries it

[147] Hansen, *Young People's Burden supra* note 109; Hansen, 2016 Declaration, *supra* note 15.
[148] USGCRP, *Climate Change Impacts*, *supra* note 118, at 23; Hansen, *Ice Melt, Sea Level Rise and Superstorms*, *supra* note 14.
[149] USGCRP, *Climate Change Impacts*, *supra* note 118, at 24.
[150] Susan Solomon et al., *Irreversible climate change due to carbon dioxide emissions*, 106 PNAS 1704, 1704–09 (2009), http://www.pnas.org/content/106/6/1704.full.pdf+html; IPCC, *AR5*, *supra* note 109, at D, 15.
[151] USGCRP, *Climate Change Impacts*, *supra* note 118, at 7.
[152] EPA, *TS Endangerment Findings*, *supra* note 123, at 26.
[153] National Science and Technology Council, Committee on Environment and Natural Resources, *Scientific Assessment of the Effects of Global Change on the United States*, at 51 (May 2008), http://ulpeis.anl.gov/documents/dpeis/references/pdfs/nstc_2008.pdf; IPCC, *AR5*, *supra* note 109, at 1.3.1, 131; USGCRP, *Climate Change Impacts*, *supra* note 118, at 22; Nat'l Aeronautics and Space Admin. ("NASA") & Goddard Institute for Space Studies ("GISS"), *Global Temperature*, https://climate nasa.gov/vital-signs/global-temperature (illustrating the change in global surface temperatures).
[154] IPCC, *AR5*, *supra* note 109, at TS.2.2.1, 37; USGCRP, *Climate Change Impacts*, *supra* note 118, at 22.
[155] IPCC, *AR5*, *supra* note 109, at TS.2.8, 50.
[156] NASA, *Facts: Climate Change: How Do We Know?: Global Temperature Rise*, https://climate.nasa.gov/evidence.
[157] IPCC, *AR5*, *supra* note 109, at B.1, 5; Hansen 2016 Declaration, *supra* note 15, at 12.
[158] NASA, *How is Today's Warming Different from the Past?*, NASA EARTH OBSERVATORY, http://earthobservatory.nasa.gov/Features/GlobalWarming/page3.php.

takes for the climate system to respond to chances in atmospheric CO_2 composition, due to the ocean's great thermal inertia, there is substantial additional warming already "in the pipeline," meaning that it is inevitable.[159] Warming already in the pipeline is mostly attributable to climate mechanisms that slowly heat the Earth's climate system in response to atmospheric CO_2.[160]

Because of year-to-year variations in these thermometer readings, scientists compare temperature differences over a decade to determine patterns.[161] Employing this decadal scale, the surface of the planet has warmed at a rate of roughly 0.12°C per decade since 1951.[162] Global mean surface temperature has been decidedly higher during the last few decades of the twentieth century than at any time during the preceding four centuries.[163] Global surface temperatures have been rising dramatically since 1951[164] and, at the time 2010 tied for the hottest year on record[165] and "January 2000 to December 2009 was the warmest decade on record," while "[t]he year 2013 tied with 2009 and 2006 for the seventh warmest year since 1880."[166] Then, 2014 became the new hottest year on record.[167] In 2015 the average global temperature "shattered the previous mark set in 2014 by 0.23 degrees Fahrenheit (0.13 Celsius)."[168] Then 2016 became the hottest year on record, making "2016 the third year in a row to set a new record for global surface temperatures."[169] "Not only was 2016 the warmest year on record, but 8 of the 12 months that make up the year – from January through September, with the exception of June – were the warmest on record for those respective months. October, November, and December of 2016 were the second warmest of those months on record – in all three cases, behind records set in 2015."[170] In 2016, the Arctic experienced its "warmest year ever, consistent with record low sea ice found in that region for most of the year."[171] Notably, 16 of the 17 hottest years on record have occurred since 2001.[172] 2017 is shaping up to be no exception to this trend; so far the year has already shown the second warmest January-March on record.[173] In July 2017, the year-to-date

[159] Hansen 2016 Declaration, *supra* note 15, at ¶ 30.
[160] Fred Pearce, *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change* 101-04 (2007) http://www.gci.org.uk/Documents/wsav.pdf; IPCC, *AR5*, *supra* note 109, at 1.2.2, 128–29.
[161] IPCC, *AR5*, *supra* note 109, at TS.2.2.1, 37.
[162] *Id.* at B.1, 5.
[163] The Nat'l Academies Press, Board on Atmospheric Sciences and Climate, *Surface Temperature Reconstructions for the Last 2,000 Years* 3 (2006), http://www nap.edu/catalog.php?record_id=11676.
[164] NASA, *Facts: Vital Signs: Global Temperature*, https://climate.nasa.gov/vital-signs/global-temperature/.
[165] NOAA, *NOAA: 2010 Ties for Warmest Year on Record* (Jan. 12, 2011), http://www.noaanews.noaa.gov/stories2011/20110112_globalstats.html.
[166] NASA, *NASA Finds 2013 Sustained Long-Term Climate Warming Trend* (January 21, 2014), https://www.nasa.gov/press/2014/january/nasa-finds-2013-sustained-long-term-climate-warming-trend/#.WQOmW1KZNE4; NASA & GISS, *2009: Second Warmest Year on Record; End of Warmest Decade*, https://www.giss.nasa.gov/research/news/20100121.
[167] NASA, *NOAA Find 2014 Warmest Year in Modern Record* (Jan. 16, 2015), http://www.nasa.gov/press/2015/january/nasa-determines-2014-warmest-year-in-modern-record.
[168] NASA, *NOAA Analyses Reveal Record-Shattering Global Warm Temperatures in 2015* (Jan. 20, 2016), http://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-record-shattering-global-warm-temperatures-in-2015.
[169] NASA, *NASA, NOAA Data Show 2016 Warmest Year on Record Globally* (Jan. 18, 2017), https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally
[170] *Id.*
[171] *Id.*
[172] *Id.*
[173] NOAA, *Assessing the U.S. Climate in March 2017* (April 6, 2017), https://www ncei noaa.gov/news/national-climate-201703.

average temperature for the contiguous U.S. was 50.9°F, 3.4°F above average. This is the second warmest on record, 1.2°F cooler than the record set in 2012.[174]

The dramatic increase of the average global surface temperature is alarming. The past several decades present an anomaly, as global surface temperatures are registering higher than at any point in the past 1,300 years.[175] The IPCC has observed that "[w]arming of the climate system is unequivocal."[176] The United States EPA has recognized the scientific consensus that has developed on the fact of global warming and its cause: the Earth is heating up due to human activities.[177]

Changes in many different aspects of Earth's climate system over the past century are consistent with this warming trend. Based on straightforward scientific principles, human-induced GHG increases lead not only to warming of land surfaces,[178] but also to the warming of oceans,[179] increased atmospheric moisture levels,[180] rises in the global sea level,[181] and changes in rainfall[182] and atmospheric air circulation patterns that affect water and heat distribution.[183]

As expected (and consistent with the temperature increases in land surfaces), ocean temperatures have also increased. Increased ocean temperatures affect the ocean's ability to circulate heat around the globe; which can have catastrophic implications for the global climate system.[184] Despite its ability to absorb enormous amounts of heat without corresponding temperature changes, the average temperature of the global ocean has increased significantly.[185] The most significant indicator of the planet's energy imbalance due to human-induced GHG increases is the long-term increase in global average ocean heat content over the last 50 years, extending down to several thousand meters below the ocean surface.[186]

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[174] NOAA, *Assessing the U.S. Climate in July 2017* (August 7, 2017), https://www.ncei noaa.gov/news/national-climate-201706.
[175] USGCRP, *Climate Change Impacts*, *supra* note 118, at 23.
[176] IPCC, *AR5*, *supra* note 109, at B, 4.
[177] EPA, *TS Endangerment Findings*, *supra* note 123, at ES-2 ("Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level . . . . Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in *anthropogenic* GHG concentrations.") (emphasis added).
[178] IPCC, *AR5*, *supra* note 109, at TS.2.2.1, 37.
[179] *Id.* at TS.2.2.3, 38.
[180] USGCRP, *Climate Change Impacts*, *supra* note 118, at 33; B.D. Santer et al., *Identification of Human-Induced Changes in Atmospheric Moisture Content*, 104 PNAS 15248, 15248–53 (Sept. 25, 2007), http://www.pnas.org/content/104/39/15248 full.pdf+html.
[181] IPCC, *AR5*, *supra* note 109, at TS.2.6, 46.
[182] USGCRP, *Climate Change Impacts*, *supra* note 118, at 26, 32–33, 36.
[183] IPCC, *AR5*, *supra* note 109, at TS.2.4, 39; Hansen, *Ice Melt, Sea Level Rise and Superstorms*, *supra* note 14.
[184] USGCRP, *Climate Change Impacts*, *supra* note 118, at 560.
[185] United Nations Environment Programme ("UNEP"), *Climate Change Science Compendium 2009*, 26 (2009), http://wedocs.unep.org/bitstream/handle/20.500.11822/7798/-Climate%20Change%20Science%20Compendium%202009-2009881.pdf?sequence=3&isAllowed=y.
[186] S. Levitus et al., *Global Ocean Heat Content 1955-2008 in Light of Recently Revealed Instrumentation Problems* 36 J. GEOPHYSICAL RES. LETTERS L07608 (Apr. 2009), http://onlinelibrary.wiley.com/doi/10.1029/2008GL037155/full.

3. Precipitation, Storms, Wildfires, and Drought

As predicted, precipitation patterns have changed due to increases in atmospheric moisture levels and changes in atmospheric air circulation patterns, another indicator that the Earth is warming.[187] As the Earth warms, moisture levels increase because warmer air holds more moisture.[188] In arid regions, however, higher temperatures lead to greater evaporation.[189]

Changes in the Earth's water cycle increase the potential for, and severity of, storms, flooding, and droughts.[190] Storm-prone areas are already experiencing a greater likelihood and incidence of severe storms and this heightened threat will continue.[191] In arid regions, increased precipitation is likely to cause flash flooding followed by drought.[192]

These changes are already occurring. Coinciding with increasing temperatures, droughts in parts of the midwestern, southeastern, and western United States have increased in frequency and severity within the last fifty years.[193] Most of the recent heat waves can be attributed to human-caused climate disruption.[194] For example, in September 2015 almost 20% of the United States experienced a severe to exceptional drought and over 50% of the United States was abnormally dry.[195] Over 40% of the western United States experienced a severe to exceptional drought[196] and 92% of California experienced a severe to exceptional drought.[197] Nearly 60 million people in the west were being affected by drought. Severe drought of this kind has significant implications for drinking water supplies, agriculture, rivers, and fish.

Based on the laws of physics and the past climate record, scientists have concluded that precipitation events will increase globally, particularly in tropical and high latitude regions, while decreasing in subtropical and mid-latitude regions,[198] with longer periods between normal heavy rainfalls.[199] In the arctic, precipitation is expected to increase by more than 50 percent as a result of anthropogenic climate change.[200] Climate change is already causing, and will continue

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[187] USGCRP, *Climate Change Impacts*, *supra* note 118, at 1, 27, 32, 36.
[188] EPA, *TS Endangerment Findings*, *supra* note 123, at 111.
[189] *Id.*
[190] *Id.*
[191] *Id.* at 120–21; USGCRP, *Climate Change Impacts*, *supra* note 118, at 43.
[192] EPA, *TS Endangerment Findings*, *supra* note 123, at 115.
[193] *Id.* at 143, 145, 148.
[194] USGCRP, *Climate Change Impacts*, *supra* note 118, at 38 ("The summer 2011 heat wave and drought in Texas was primarily driven by precipitation deficits, but the human contribution to climate change approximately doubles the probability that the heat was record-breaking.").
[195] *See* United States Department of Agriculture, U.S. Drought Monitor Map Archive (September 15, 2015 national data set) http://droughtmonitor.unl.edu/MapsAndData/MapArchive.aspx.
[196] *See* United States Department of Agriculture, U.S. Drought Monitor Map Archive (September 15, 2015 Climate Region: West data set) http://droughtmonitor.unl.edu/MapsAndData/MapArchive.aspx.
[197] *See* United States Department of Agriculture, U.S. Drought Monitor Map Archive (September 15, 2015 State: California data set) http://droughtmonitor.unl.edu/MapsAndData/MapArchive.aspx.
[198] EPA, *TS Endangerment Findings*, *supra* note 123, at ES-4, 74.
[199] *Id.*
[200] R. Bintanja & FM Selton, *Future Increases in Arctic Precipitation Linked to Local Evaporation and Sea-Ice Retreat*, 509 NATURE 479–82 (2014).

to cause, more frequent, extreme, and costly weather events (such as hurricanes).[201] Coinciding with increasing temperatures in the Atlantic sea surface, the annual number of major tropical storms and hurricanes has increased over the past 100 years in North America.[202]

Other changes consistent with climate modeling resulting from global warming have been observed. These include not only in the amount, intensity, and frequency of precipitation but also in the type of precipitation.[203] In higher altitude and latitude regions, including in mountainous areas, more precipitation is falling as rain rather than snow.[204] With early snow melt occurring because of climate change, the reduction in snowpack can aggravate water supply problems.[205] The snow cover extent of North America in June 2013 was the fourth lowest ever recorded.[206] According to a snow report from April 2015, snow cover extent for the contiguous U.S. was 161,000 square miles, which is 121,000 square miles below the 1981-2010 average.[207] This means the April 2015 snow cover extent was the 10th smallest on record and the smallest since 2012.[208] In March 2016, the snow cover for the contiguous U.S. was 382,000 square miles, 359,000 square miles below the 1981-2010 average and the second smallest snow cover in the 50-year period for which records exist.[209] In March 2017, the snow cover for the contiguous U.S. was yet again below the 1981-2010 average, this time by 81,000 square miles, the 19th smallest in the 51-year period of record.[210]

As the 2010 Russian summer heat wave graphically demonstrated, heat can destroy crops, trigger wildfires, exacerbate air pollution, and cause increased illness and deaths.[211] Similar impacts are occurring across the United States. The "number and frequency of forest fires and insect outbreaks are increasing in the interior West, the Southwest, and Alaska. Precipitation and stream temperatures are increasing in most of the continental United States. The western United States is experiencing reduced snowpack and earlier peaks in spring runoff. The growth of many crops and weeds is being stimulated."[212] Climate change and ocean acidification are threatening the survival and wellbeing of millions of species of plants, fish and

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[201] USGCRP, *Climate Change Impacts*, *supra* note 118, at 38.
[202] NSTC, *Scientific Assessment*, *supra* note 153, at 7.
[203] *Id.* at ES-2.
[204] USGCRP, *Climate Change Impacts*, *supra* note 118, at 75.
[205] *Id.* at 72.
[206] *Arctic Ice Loss Rate Moderated in 2013 Says NOAA* (Dec. 13, 2013) http://archive.reportingclimatescience.com/archivenews/article/arctic-ice-loss-rate-moderated-in-2013-says-noaa html ("[T]he below normal June SCE in North America was driven by rapid snow melt, rather than anomalously low snow accumulation prior to melt onset.").
[207] NOAA National Centers for Environmental Information, *State of the Climate: National Snow and Ice for April 2015*, http://www.ncdc noaa.gov/sotc/snow/201504.
[208] *Id.*
[209] NOAA National Centers for Environmental Information, *National Snow and Ice – March 2016*, http://www.ncdc noaa.gov/sotc/snow/201603.
[210] NOAA National Centers for Environmental Information, *National Snow and Ice – March 2017*, https://www.ncdc noaa.gov/sotc/snow/201703.
[211] *See* NOAA Earth System Research Lab, *The Russian Heat Wave 2010* (Sept. 2010), http://www.esrl.noaa.gov/psd/csi/moscow2010.
[212] EPA, *TS Endangerment Findings*, *supra* note 123, at 25 (citing P. Backlund et al., *Executive Summary*, *in* THE EFFECTS OF CLIMATE CHANGE ON AGRICULTURE, LAND RESOURCES, WATER RESOURCES, AND BIODIVERSITY IN THE UNITED STATES (2008)).

wildlife, and Earth's biodiversity. As many as one in six species are threatened with extinction due to climate change.[213] Many more species that do not face extinction will face changes in abundance, distributions, and species interactions that cause adverse impacts for ecosystems and humans.[214]

Climate change, and related warmer temperatures and drought, are leading to longer and more destructive wildfire seasons. In 2015 for example, Alaskan wildfires burned over 5 million acres.[215] Alaska's 2015 wildfire season was the second worse since records began in 1940, exceeded only by the 2004 record-breaking wildfire season.[216] As the American Meteorological Society concluded, anthropogenic climate change has increased the risk of fire seasons of this severity in Alaska by 34-60%.[217] Wildfires likewise ravaged areas throughout the western United States. The Governor of Washington, Jay Inslee, referred to the 2015 wildfire situation in Washington as "an unprecedented cataclysm."[218] Fires burned millions of acres, destroyed hundreds of homes, and caused multiple fatalities. Indeed, the 2015 fire season set an ominous record: for the first time on record U.S. wildfires burned more than 10 million acres.[219] 2015 was also the most expensive wildfire season on record with over $1.7 billion spent to fight fires.[220] Wildfire seasons are only expected to get increasingly destructive, dangerous, and expensive in the coming years as a result of climate change.[221]

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[213] Mark C. Urban, *Accelerating Extinction Risk from Climate Change*, 348 SCIENCE 6234 (2015), http://science.sciencemag.org/content/348/6234/571 full.

[214] Johan Ehrlen and William Morris, *Predicting Changes in the Distribution and Abundance of Species Under Environmental Change*, Ecology Letters, (Mar. 18, 2015), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4674973/.

[215] Asaf Shalev, *2015 Alaska Wildfire Season Now 2nd Biggest on Record*, ALASKA DISPATCH NEWS (Aug. 10, 2015), http://www.adn.com/article/20150810/2015-alaska-wildfire-season-now-2nd-biggest-record.

[216] J. L. Partain & Coauthors, *2016: An Assessment of the Role of Anthropogenic Climate Change in the Alaska Fire Season of 2015, in* EXPLAINING EXTREME EVENTS OF 2015 FROM A CLIMATE CHANGE PERSPECTIVE, *Bull. Amer. Meteor. Soc.*, 97 (12), S14, available at https://www.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/explaining-extreme-events-from-a-climate-perspective.

[217] *Id.* at S17.

[218] CNN, *Wildfires Roar Throughout Washington State, Governor Says* (Aug. 20, 2015), http://www.cnn.com/2015/08/20/us/wildfires-western-states.

[219] National Interagency Fire Center, Total Wildland Fires and Acres (1960–2015), https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires html.

[220] Doyle Rice, *2015 Now USA's Costliest Wildfire Season on Record*, USA TODAY (Dec. 17, 2015), https://www.usatoday.com/story/news/nation/2015/12/16/costliest-wildfire-season-record/77417982/.

[221] Partain, J. L., and Coauthors, 2016: An Assessment of the Role of Anthropogenic Climate Change in the Alaska Fire Season of 2015, *supra* note 216, at S17 (Concluding that anthropogenic climate change has increased risk of severe wildfires in Alaska by 34–60%, consistent "with the similar finding by Yoon et al. (2015) for wildfires in California, where an increased wildfire risk relative to the preindustrial climate emerged in the 1990s. Similar model-derived results were found for the western United States (Luo et al. 2013; Yue et al. 2013), Canada (Flannigan et al. 2015), and Alaska (Young et al. 2016)."); *see also* M.D. Flannigan et al., *Fuel Moisture Sensitivity to Temperature and Precipitation: Climatic Change Implications*, CLIMATIC CHANGE 134, 59–71 (2015), https://link.springer.com/article/10.1007/s10584-015-1521-0; L. F. Luo et al., *Will Future Climate Favor More Erratic Wild Fires in the Western United States?* J. APPL. METEOR. CLIMATOL., 52, 2410–17 (2013), http://journals.ametsoc.org/doi/full/10.1175/JAMC-D-12-0317.1; A.M. Young et al., *Climate Thresholds Shape Northern High Latitude re Regimes and Imply Vulnerability to Future Climate Change*, ECOGEOGRAPHY (2016), http://files.cfc.umt.edu/phiguera/publications/Young_et_al_2016_Ecography.pdf; X. Yue et al., *Ensemble Projections of Wild Reactivity and Carbonaceous Aerosol Concentrations over the Western United States in the Mid-21st century*, 77 ATMOS. ENVIRON., 767–80 (2013), https://www.ncbi nlm nih.gov/pmc/articles/PMC3763857/.

4. Sea Level Rise

As expected, global sea levels have also risen, and are expected to continue to rise at an exponential, not linear, rate.[222] Based on measurements taken from 1993-2010, sea levels have been rising at an average rate of 3.2 millimeters per year.[223] Though sea levels rose about 8 inches over the last century, within the last decade, that rate has nearly doubled.[224] Ice melt doubling of 10, 20, or 40 years would result in sea level rise of several meters in 50, 100, or 200 years respectively and, as evidenced by recent ice melting, it appears that the ice melt doubling time is currently at the low end of the 10-40 year range.[225] Rising seas, brought about by melting of polar icecaps and glaciers, as well as by thermal expansion of the warming oceans, will cause flooding in coastal and low-lying areas.[226] The combination of rising sea levels and more severe storms creates conditions conducive to severe storm surges during high tides.[227] In coastal communities this can overwhelm coastal defenses (such as levees and sea walls), as witnessed during Hurricane Katrina and Hurricane Sandy.[228] Because of the long time that CO_2 persists in the climate system, without immediate and rapid reductions in CO_2 emissions we will lock in catastrophic consequences, including multi-meter sea level rise. This would mean that all coastal cities would "los[e] functionality" with "practically incalculable" economic and social costs.[229] Relying on adaptation to these threats "will be unacceptable to most of humanity."[230]

Sea level is not uniform across the globe because it depends on variables such as ocean temperature and currents.[231] Unsurprisingly, the most vulnerable lands are low-lying islands, river deltas, and areas that already lie below sea level because of land subsidence.[232] Based on these factors, scientists have concluded that the immediate threats to the United States from rising seas are the most severe on the Gulf and Atlantic Coasts.[233] Worldwide, hundreds of millions of people live in river deltas and vulnerable coastlines.[234]

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[222] Hansen, *Ice Melt, Sea Level Rise and Superstorms*, *supra* note 15, at 3761; USGCRP, *Climate Change Impacts*, *supra* note 118, at 44; EPA, *TS Endangerment Findings*, *supra* note 123, at ES-3; IPCC, *AR5*, *supra* note 109, at B.4, 11.

[223] IPCC, *AR5*, *supra* note 109, at B.4, 11.

[224] NASA, *Facts: Evidence: Climate Change: How Do We Know? -Sea Level Rise*, http://climate.nasa.gov/evidence/#no4 (citing J.A. Church & N.J. White, *A 20th Century Acceleration in Global Sea Level Rise*, 33 GEOPHYSICAL RESEARCH LETTERS (2006), http://onlinelibrary.wiley.com/doi/10.1029/2005GL024826/full).

[225] Hansen, *Ice Melt, Sea Level Rise and Superstorms*, *supra* note 15, at 3761.

[226] EPA, *TS Endangerment Findings*, *supra* note 123, at ES-7; USGCRP, *Climate Change Impacts*, *supra* note 118, at 45.

[227] USGCRP, *Climate Change Impacts*, *supra* note 118, at 45; EPA, *TS Endangerment Findings*, *supra* note 123, at 75.

[228] EPA, *TS Endangerment Findings*, *supra* note 123, at 86, 118.

[229] Hansen, *Ice Melt, Sea Level Rise and Superstorms*, *supra* note 15, at 3762.

[230] *Id.*

[231] IPCC, *AR5*, *supra* note 109, at E.6, 26.

[232] EPA, *TS Endangerment Findings*, *supra* note 123, at 121.

[233] *Id.* at 128; USGCRP, *Climate Change Impacts*, *supra* note 118, at 589 (Annual damage resulting from sea level rise "in the Gulf region alone could be $2.7 to $4.6 billion by 2030, and $8.3 to $13.2 billion by 2050.").

[234] EPA, *TS Endangerment Findings*, *supra* note 123, at 159.

If carbon pollution is not quickly abated, there is near scientific certainty that humanity will experience sea level rise of several meters this century,[235] submerging much of the eastern seaboard of the U.S., as well as low lying areas of Europe, the Far-East, and the Indian sub-continent. This would mean that we would lose the functionality of all coastal cities, with "incalculable" economic and socials costs.[236] "Today, rising sea levels are submerging low-lying lands, eroding beaches, converting wetlands to open water, exacerbating coastal flooding, and increasing the salinity of estuaries and freshwater aquifers."[237] Low-lying lands are especially vulnerable to sea level rise. Scientists have predicted that wetlands in the Mid-Atlantic region of the United States cannot withstand a 7-millimeter per year rise in sea levels.[238] As wetlands are inundated, further impacts from sea level rise will multiply, as "protection of coastal lands and people against storm surge will be compromised."[239]

Glacial and ice cap melting is one of the major indicators of global warming and is a significant cause of global sea level change.[240] When glaciers and ice caps melt, this adds water to the ocean.[241] As a result of these interlocking changes, "sea level rise is expected to continue well beyond this century as a result of both past and future GHG emissions from human activities."[242]

5. Glaciers, Sea Ice, and Permafrost

As expected, mountain glaciers, which are the source of freshwater for hundreds of millions of people, are receding worldwide because of warming temperatures.[243] In the Brooks Range of northern Alaska, all of the glaciers are in retreat and in southeastern Alaska 98% are in retreat.[244] In 2010, Glacier National Park in Montana had only twenty-five glaciers larger than twenty-five acres, down from one hundred and fifty in 1850.[245] These glaciers may be completely gone in the coming decades.[246] Mountain glaciers are in retreat all over the world,

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[235] Hansen, *Ice Melt Sea Level Rise and Superstorms*, *supra* note 9, at 3761–62, 3800.
[236] *Id.* at 20062.
[237] U.S. Climate Change Science Program ("USCCSP"), *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region* 2 (Jan. 2009), http://downloads.globalchange.gov/sap/sap4-1/sap4-1-final-report-all.pdf [hereinafter *Coastal Sensitivity to Sea-Level Rise*].
[238] *Id*, at 4.
[239] USGCRP, *Climate Change Impacts*, *supra* note 118, at 402.
[240] EPA, *Climate Change Indicators in the United States* 56–61 (2014), https://www.epa.gov/sites/production/files/2016-07/documents/climateindicators-full-2014.pdf; *see also* EPA, *Climate Change Indicators in the United States* (2016), https://www.epa.gov/sites/production/files/2016-08/documents/climate_indicators_2016.pdf.
[241] USGCRP, *Climate Change Impacts*, *supra* note 118, at 44.
[242] *Id.* at 45.
[243] *See TS Endangerment Findings*¸ *supra* note 123, at 111 ("Glaciers throughout North America are melting, and the particularly rapid retreat of Alaskan glaciers represents about half of the estimated loss of glacial mass worldwide.").
[244] Lonnie G. Thompson, *Climate Change: The Evidence and Our Options*, 2 BEHAVIOR ANALYST 153, 158 (Fall 2010), https://www ncbi.nlm.nih.gov/pmc/articles/PMC2995507/.
[245] United States Geological Survey (Northern Rocky Mountain Science Center), *Retreat of Glaciers in Glacier National Park* (May 2013), https://www.nps.gov/subjects/climatechange/upload/USGS_GlacRetreat_2013.pdf.
[246] Annie Minard, *No More Glaciers in Glacier National Park by 2020?*, NATIONAL GEOGRAPHIC (March 2, 2009), http://news.nationalgeographic.com/news/2009/03/090302-glaciers-melting.html.

including on Mt. Kilimanjaro, in the Himalayas and the Alps (99% in retreat), among the glaciers of Peru and Chile (92% in retreat), and in the United States.[247]

Although a relatively minor contribution to sea level rise, the melting of mountain glaciers is serious in areas that rely on snow melt for irrigation and drinking water supply.[248] A large snow pack or glacier acts as a supplemental reservoir, holding a great deal of water in the form of ice and snow through the winter and spring and releasing it in the summer when rainfall is lower or absent.[249] The water systems of the western United States (particularly California) and the Andean nations of Peru and Chile, among other places, all heavily rely on these natural forms of water storage.[250] In addition to providing a more reliable water supply, the storing of precipitation as ice and snow helps moderate potential flooding.[251] Yet as temperatures warm, not only will these areas lose this supplemental form of water storage, but also severe flooding is likely to increase (because when rain falls on snow, it accelerates the melting of glaciers and snow packs).[252]

Scientists have also documented an overall trend of Arctic sea ice thinning.[253] The arctic sea ice (frozen ocean water) extent for March 2017 was "the lowest in the satellite record for the month."[254] Arctic sea ice plays an important role in stabilizing the global climate because it reflects back into space much of the solar radiation that the region receives.[255] In contrast, open ocean water absorbs much more heat from the sun, thus, amplifying human-induced warming and creating an increased global warming effect.[256] As Arctic sea ice decreases, the region is less capable of stabilizing the global climate and may act as a feedback loop (thereby aggravating global warming).[257] Arctic sea ice is declining precipitously and is expected to disappear completely in the coming decades.[258] During the 2007 melt season, the extent of Arctic sea ice declined precipitously to what was then its lowest level since satellite measurements began in 1979.[259] In 2013, Arctic sea ice extent for September was 700,000 square miles less than the

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[247] Thompson, *supra* note 244, at 155–60; USGCRP, *Climate Change Impacts*, *supra* note 118, at 45.
[248] IPCC, *AR5*, *supra* note 109, at 9.3.2, 7.
[249] *See* Thompson, *Climate Change: The Evidence and Our Options*, *supra* note 244, at 164.
[250] *See id.* at 155–60, 164.
[251] EPA, *TS Endangerment Findings*, *supra* note 123, at 111.
[252] *Id.*
[253] NOAA, National Centers for Environmental Information, *Global Snow and Ice – March 2017*, https://www.ncdc noaa.gov/sotc/global-snow/201703.
[254] National Snow and Ice Data Center ("NSIDC"), Press Release, *Another Record, but a Somewhat Cooler Arctic Ocean* (April 11, 2017), https://nsidc.org/arcticseaicenews/2017/04/another-record-but-a-somewhat-cooler-arctic-ocean.
[255] EPA, *Climate Change Indicators in the United States*, (2014) supra note 240 at 58.
[256] *Id*.
[257] *Id.*
[258] USGCRP, *Climate Change Impacts*, *supra* note 118, at 28 ("The observed drastic reduction in sea ice can also lead to a "tipping point" – a point beyond which an abrupt or irreversible transition to a different climate state occurs. In this case, the dramatic loss of sea ice could tip the Arctic Ocean into a permanent, nearly ice-free state in summer, with repercussions that may extend far beyond the Arctic.").
[259] NSIDC, Press Release, *Arctic Sea Ice Shatters All Previous Record Lows* (Oct. 1, 2007), http://nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease html; EPA, *TS Endangerment Findings*, *supra* note 123, at 27 ("Average arctic temperatures increased at almost twice the global average rate in the past 100 years.").

1981-2010 average for the same period.[260] In 2014, the Arctic sea ice extent for September was 463,000 square miles below average.[261] In 2015, the maximum extent of the Arctic sea ice was the lowest in the satellite record at the time.[262] The 2015 record was broken just a year later, in 2016, when the wintertime extent of the arctic sea ice hit another record low, according to NASA.[263] This record was again broken, for the third straight year, in 2017, when an all-time record low maximum extent of arctic sea ice coincided with a historic low minimum extent for Antarctic sea ice.[264] With less sea ice, less solar radiation is reflected back to space. Thus, these tends reflect that the melting of ice is part of a positive feedback loop that amplifies warming.

Similarly, there has been a general increase in permafrost temperatures and permafrost melting in Alaska and other parts of the Arctic.[265] Because much of the Arctic permafrost overlays old peat bogs, scientists believe (and are concerned) that the thawing of the permafrost[266] may release methane that will further increase global warming to even more dangerous levels.[267] Indeed, substantial methane releases from thawing permafrost have been detected in Alaska and Siberia.[268] The amount of carbon dioxide emitted from northern tundra areas in Alaska between October and December each year has increased 70 percent since 1975.[269] Carbon dioxide and methane released from thawing permafrost could contribute "as much as 0.4° F to 0.6° F of warming by 2100."[270]

Beginning in late 2000, the Jakobshavn Isbrae Glacier (which has a major influence over the mass of the Greenland ice sheet) lost significant amounts of ice.[271] In August 2010, an enormous iceberg (roughly ninety-seven square miles in size) broke off from Greenland.[272] In the especially hot summer of 2012, Greenland's Rink Glacier, which typically drains about 11 billion tons (11 gigatons) of ice per year in the early 2000s, lost an additional 6.7 gigatons of

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[260] NSIDC, Press Release, *A Slow and Bumpy Climb* (Jan. 8, 2014), http://nsidc.org/arcticseaicenews/2014/01/a-slow-and-bumpy-climb.
[261] NSIDC, Press Release, *Arctic Sea Ice Reaches Minimum Extent for 2014* (Sept. 22, 2014), http://nsidc.org/arcticseaicenews/2014/09/arctic-minimum-reached.
[262] NASA, *2015 Arctic Sea Ice Maximum Annual Extent Is Lowest on Record* (Mar. 19, 2015), https://www.nasa.gov/content/goddard/2015-arctic-sea-ice-maximum-annual-extent-is-lowest-on-record.
[263] NASA, *2016 Arctic Sea Ice Wintertime Extent Hits Another Record Low*, (Mar. 28, 2016), http://www.nasa.gov/feature/goddard/2016/2016-arctic-sea-ice-wintertime-extent-hits-another-record-low.
[264] NASA, *Sea Ice Extent Sinks to Record Lows at Both Poles* (Mar. 22, 2017), https://www.nasa.gov/feature/goddard/2017/sea-ice-extent-sinks-to-record-lows-at-both-poles.
[265] IPCC, *AR5*, *supra* note 109, at 4.3.3.4, 46.
[266] USGCRP, *Climate Change Impacts*, *supra* note 118, at 48.
[267] *See* IPCC, *AR5*, *supra* note 109, at 149; USGCRP, *Climate Change Impacts*, *supra* note 118, at 48.
[268] USGCRP, *Climate Change Impacts*, *supra* note 118, at 48.
[269] Ellen Gray (NASA) *Alaska Tundra Source of Early-Winter Carbon Emissions* (May 8, 2017), https://www.nasa.gov/feature/jpl/alaska-tundra-source-of-early-winter-carbon-emissions.
[270] *Id*.
[271] Gary Braasch & Bill McKibben, *Earth Under Fire: How Global Warming is Changing the World*, 18–20 (2009); *see also* J.E. Box et al., *Greenland*, *in Arctic Report Card: Update for 2010*, 55 (Oct. 19, 2010), ftp://ftp.oar noaa.gov/arctic/documents/ArcticReportCard_full_report2010.pdf ("A clear pattern of exceptional and record-setting warm air temperatures is evident at long-term meteorological stations around Greenland.").
[272] NASA Earth Observatory, *Ice Island Calves Off Petermann Glacier* (Aug. 2010), http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=45112&src=eorss-nh.

mass in a solitary melt event lasting four months.[273] Nine Antarctic ice shelves have also collapsed into icebergs in the last fifty years (six of them since 1996).[274] An ice shelf roughly the size of Rhode Island collapsed in 2002, and an ice bridge collapsed in 2009, leaving an ice shelf the size of Jamaica on the verge of shearing off.[275] The 2002 collapse of the Larsen Ice Shelf, which had existed for at least 11,000 years, was "unprecedented in respect to both area and time."[276] The "sudden and complete disintegration" of the Larsen Ice Shelf took a mere 35 days.[277]

Most recently, scientific reports warn of the disintegration of both the West Antarctic ice sheet and the East Antarctic ice sheet, causing multi-meter sea-level rise.[278] Such sea level rise will devastate coastal regions, including much of the eastern seaboard. Millions of Americans and trillions of dollars in property damage will result. The risk of this devastation approaches certainty, unless fossil fuel emissions are rapidly phased out. The recent studies more fully account for the potential for non-linear ice sheet melting, which could raise the sea level by 10 feet (or more) by mid-century.[279] The rate of melting for these ice sheets is exceeding scientists' expectations, requiring scientists to forecast even greater increases in global sea level rise.[280]

6. Ocean Acidification

The negative effects of increased CO_2 emissions are not limited to changes in our climate systems. Rather, CO_2 emissions are also having a severe impact on our oceans. As it stands, the oceans absorb around 30% of global CO_2 emissions.[281] This absorption has greatly mitigated the effects CO_2 otherwise would have had on our climate.[282] However, the cost of this mitigation has been a pernicious change in our ocean's chemistry.[283]

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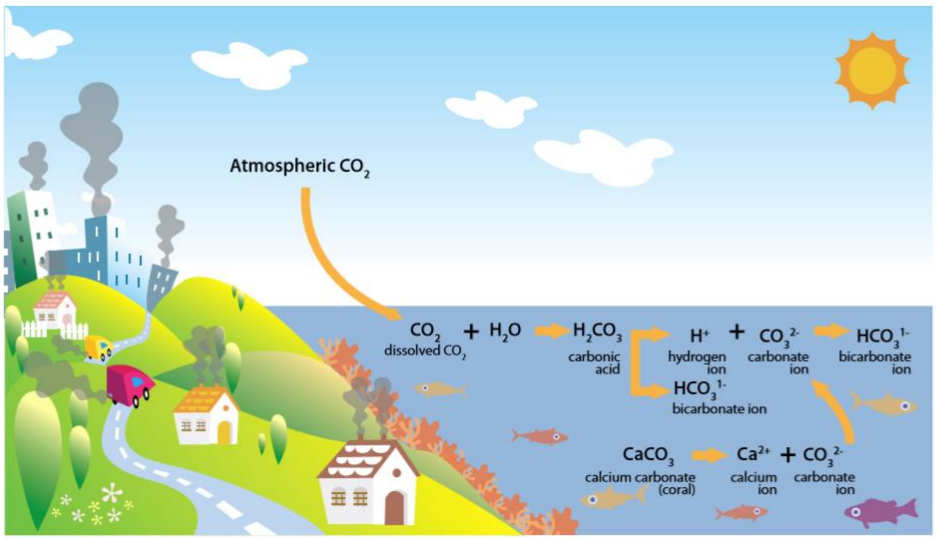
[273] Carol Rasmussen, *NASA Discovers a New Mode of Ice Loss in Greenland*, NASA (May 25, 2017), https://www.nasa.gov/feature/jpl/nasa-discovers-a-new-mode-of-ice-loss-in-greenland.
[274] Alister Doyle, *Antarctic Ice Shelf Set to Collapse Due to Warming*, REUTERS (Jan. 19, 2009), http://www.reuters.com/article/idUSTRE50I4G520090119.
[275] NASA Earth Observatory, *Wilkins Ice Bridge Collapse* (Apr. 2009), http://earthobservatory.nasa.gov/IOTD/view.php?id=37806.
[276] U.S. Geological Survey, *Coastal-Change and Glaciological Map of the Larsen Ice Shelf Area, Antarctica: 1940-2005* at 10 (2008), http://pubs.usgs.gov/imap/2600/B/LarsenpamphletI2600B.pdf.
[277] *Id.*
[278] NASA, *NASA-UCI Study Indicates Loss of West Antarctic Glaciers Appears Unstoppable* (May 12, 2014), http://www.nasa.gov/press/2014/may/nasa-uci-study-indicates-loss-of-west-antarctic-glaciers-appears-unstoppable/#.U5jBk_ldV3H; J.S. Greenbaum et al., *Ocean Access to a Cavity Beneath Totten Glacier in East Antarctica*, 8 NATURE GEOSCIENCE 294 (Apr. 2015).
[279] *Id.*; Hansen, *Ice Melt, Sea Level Rise and Superstorms*, *supra* note 15, at 3800.
[280] Hansen, *Ice Melt, Sea Level Rise and Superstorms*, *supra* note 15, at 3761; Hannah Hickey, *West Antarctic Ice Sheet Collapse is Under Way*, UNIVERSITY OF WASHINGTON (May 12, 2014), http://www.washington.edu/news/2014/05/12/west-antarctic-ice-sheet-collapse-is-under-way.
[281] Ellycia Harrould-Kolieb & Jacqueline Savitz, *Acid Test: Can We Save Our Oceans From CO_2?*, OCEANA 2 (2d ed. 2009), http://www.salemsound.org/PDF/Acidification_Report-09.pdf [hereinafter *Acid Test*].
[282] *Id.*
[283] *Id.*

Ocean acidification is defined as "a reduction in the pH of seawater for an extended period due primarily to the uptake of carbon dioxide from the atmosphere by the ocean."[284] Over the last 250 years, humans have increased atmospheric CO_2 concentrations by 40%.[285] The oceans, in turn, have absorbed about a quarter of this CO_2.[286] As CO_2 has been absorbed and dissolved in the seawater it has had an acidifying effect.[287] As a result, "[o]ver the last 250 years, the average upper-ocean pH has decreased by about 0.1 units, from about 8.2 to 8.1."[288] This drop in pH corresponds with a 30% increase in surface ocean acidity.[289]

This carbon dioxide absorption and resulting acidity in oceans cause a decrease in the concentration of carbonate ions, which threatens the formation of calcium carbonate shells and skeletons in many marine organisms. When CO_2 enters into solution with water (H_2O), carbonic acid (H_3CO_2) is formed. The carbonic acid then breaks down, releasing a bicarbonate ion (HCO_3) and a hydrogen ion (H+).[290] As increasing quantities of CO_2 dissolve in seawater, the concentration of hydrogen ions increases, causing a decrease in pH (pH is inversely proportional to the concentration of hydrogen ions: the greater the concentration of hydrogen ions, the lower the pH) and an increase in acidity.[291] The newly free hydrogen ion then bonds with a free carbonate ion, forming another bicarbonate ion (HCO_3-).[292] Thus as the concentration of hydrogen ions increases, the concentration of carbonate decreases.[293] This is significant because carbonate is essential to many life-functions, such as forming calcium carbonate shells and skeletons.[294] This process has been described in the Figure 1 below:[295]

[284] Washington State Blue Ribbon Panel on Ocean Acidification, *Ocean Acidification: From Knowledge to Action, Washington State's Strategic Response,* xi (H. Adelsman & L. Whitely Binder eds., 2012) https://fortress.wa.gov/ecy/publications/publications/1201015.pdf [hereinafter *Strategic Response*].
[285] *Id.* at 9.
[286] *Id.*
[287] *Id.*
[288] *Id.*
[289] *Id.*
[290] Harrould-Kolieb, *Acid Test*, *supra* note 281, at 8.
[291] *Id.*
[292] *Id.*
[293] *Id.*
[294] *Id.*
[295] *Id.*

Figure 1: The Chemistry of Ocean Acidification



As CO_2 is absorbed by the atmosphere it bonds with sea water forming carbonic acid. This acid then releases a bicarbonate ion and a hydrogen ion. The hydrogen ion bonds with free carbonate ions in the water forming another bicarbonate ion. This free carbonate would otherwise be available to marine animals for making calcium carbonate shells and skeletons.

Ocean acidity has been rising at a geologically unprecedented rate. Currently, acidity is rising at least 100 times faster than at any other period during the last 100,000 years.[296] There have been periods during which levels of atmospheric CO_2 concentration and ocean acidity were higher than today's levels. However, the rate at which these levels were reached was much slower than the rate at which atmospheric CO_2 and oceanic pH are changing today.[297] For example, around 55 million years ago, during the Paleocene-Eocene Thermal Maximum (PETM), atmospheric CO_2 concentrations increased to around 1800 ppm and the pH of the oceans declined by around 0.45 units over roughly 5000 years.[298] This rise in pH resulted in an extinction event, during which "about half of benthic foraminifera (tiny shelled protists) species went extinct over a 1000-year period."[299] Today, the rate at which acidity is rising is nearly ten times faster than during the period leading up the PETM extinction event.[300] The danger here is that the rate of acidification may outpace the natural capacity of the ocean to buffer the excess CO_2 levels.[301] Scientists have projected that if anthropogenic CO_2 emissions continue at present

[296] *Id.* at 7
[297] Washington State Blue Ribbon Panel on Ocean Acidification, *Scientific Summary of Ocean Acidification in Washington State Marine Waters*, 9, (2012), https://fortress.wa.gov/ecy/publications/documents/1201016.pdf [hereinafter *Scientific Summary of Ocean Acidification*].
[298] *Id.*; P. Jardine, *Patterns in Paleontology: The Paleocene-Eocene Thermal Maximum*, Paleontology Online (Jan. 10, 2011), http://www.palaeontologyonline.com/articles/2011/the-paleocene-eocene-thermal-maximum.
[299] *Scientific Summary of Ocean Acidification*, *supra* note 297, at 9.
[300] *Id.*
[301] *Id.*

trends, oceanic pH may drop another 0.5 units by 2100, a threefold decrease from pre-industrial times. [302] Such a drop would also bring oceanic pH outside the natural range of variation.[303]

The oceans have a limited ability to buffer increases in the availability of hydrogen ions.[304] As the concentration of hydrogen ions increases due to increased concentrations of atmospheric CO_2, more of these newly available hydrogen ions react with carbonate ions to form bicarbonate.[305] This process, known as a carbonate buffer, then reduces the total resulting decrease in pH.[306] However, as more and more carbonate is consumed through the natural dissolution of CO_2, and through the buffering processes, "[t]he capacity of the buffer to restrict pH changes diminishes as increased amounts of CO_2 are absorbed by the oceans."[307] As a result, as carbonate ions become less readily available, the oceans will acidify at increasingly rapid rates.[308]

Many important marine organisms, including shellfish and corals, require sufficient concentrations of carbonate and bicarbonate in order to build structures, such as shells, out of calcium carbonate ($CaCO_3$).[309] Calcium carbonate will dissolve in seawater unless the water is saturated with carbonate ions.[310] Calcium carbonate also becomes more soluble as temperature decreases and pressure increases.[311] As a result, as depth increases, causing temperature to decrease and pressure to increase, calcium carbonate becomes more soluble.[312]These variables (carbonate ion concentrations, temperature, and pressure) interact to create a natural barrier, known as a saturation horizon, below which calcium carbonate will dissolve, and above which calcium carbonate is capable of forming.[313] As more and more anthropogenic CO_2 has dissolved, the carbonate ion concentration has decreased causing the saturation horizon for calcium carbonate to rise.[314] To survive, calcium carbonate-dependent species must live above the saturation horizon.[315] As the saturation horizon rises, it poses a greater threat to calcium carbonate-dependent marine species by encroaching upon their habitat.[316]

The shoaling, or rising, of calcite and aragonite (two forms of calcium carbonate) saturation horizons poses a real threat to the world's coral reefs. Scientists have found that "where coral reefs occur, carbonate-ion concentrations over the past 420,000 years have not

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[302] The Royal Society, *Ocean Acidification Due to Increasing Atmospheric Carbon Dioxide*, vi (2005), https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2005/9634.pdf.
[303] *Id.*
[304] *Id.* at 6.
[305] *Id.*
[306] *Id.*
[307] *Id.* at 6.
[308] *Id.*
[309] *Id.* at 10.
[310] *Id.*
[311] *Id.*
[312] *Id.*
[313] *Id.*
[314] *Id.*
[315] *Id.* at 11.
[316] *Id.*

fallen below 240 mmol kg^{-1}."[317] Today, "carbonate-ion concentrations (~210 mmol kg^{-1}) [are] lower than at any other time during the past 420,000 years."[318] Today, coral reefs are not found in waters with aragonite concentrations below 3.25 mmol kg^{-1}.[319] As the concentration of atmospheric carbon dioxide increases, the potentially viable coral habitats decrease.[320] The current rate at which carbonate ion concentrations are decreasing is likely to outpace the ability of the world's corals to adapt to, let alone mitigate against, the changes.[321]

Over the past 136 years (from 1870-2006) atmospheric CO_2 changed 136 times faster than during the previous 420,000 years, and temperature changed 70 times faster.[322] As the present and projected future rates of change "dwarf even those of the ice age transitions…it is likely that [the rate of these] changes will exceed the capacity of most organisms to adapt."[323] Given that "[c]oral reefs are among the most biologically diverse and economically important ecosystems on the planet, providing ecosystem services that are vital to human societies and industries through fisheries, coastal protection, building materials, new biochemical compounds, and tourism," the impact of their loss on the planet cannot be overstated.[324] The impacts of ocean acidification to Alaska's fisheries are likely to be similarly devastating (See Section VI.B.4.b).

7. Agricultural and Forest Losses

Changes in water supply and water quality resulting from climate change will impact agriculture in the United States.[325] Additionally, increased heat and associated issues such as pests, crop diseases, and weather extremes, will all impact crop and livestock production and quality.[326] For example, climate change in the United States has produced warmer summers, enabling the mountain pine beetle to produce two generations of beetles in a single summer season, where it had previously only been able to produce one. In Alaska, the spruce beetle is maturing in one year when it had previously taken two years.[327] The expansion of the forest beetle population has killed millions of hectares of trees across the United States and Canada and resulted in millions of dollars lost from decreased timber and tourism revenues.[328]

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[317] O. Hoegh-Guldberg et al., *Coral Reefs Under Rapid Climate Change and Ocean Acidification*, 318 SCIENCE 1757, 1757 (2007), http://science.sciencemag.org/content/318/5857/1737 full.
[318] *Id*.
[319] *Id*. at 1740.
[320] *Id.*
[321] *Id.* at 1738.
[322] *Id.*
[323] *Id*. at 1737.
[324] *Id.*
[325] USGCRP, *Climate Change Impacts*, *supra* note 118, at 161; *see* United States Department of State ("USDS"), *2014 Climate Action Report to the UN Framework Convention on Climate Change* 154-55 (2014), https://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/2014_u.s._climate_action_report%5B1%5Drev.pdf, [hereinafter *Climate Action Report*].
[326] USDS, *Climate Action Report*, *supra* note 325, at 154–55.
[327] U.S. Climate Change Science Program ("USCCSP"), *Weather and Climate Extreme in a Changing Climate, Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands*, 15 (June 2008) https://www.climatecommunication.org/wp-content/uploads/2012/01/climateextremes.pdf, [hereinafter *Weather and Climate Extremes*].
[328] *Id.*

Agriculture is extremely susceptible to climate changes and higher temperatures generally reduce yields of desirable crops while promoting pest and weed[329] proliferation.[330] Global climate change is predicted to decrease crop yields, increase crop prices, decrease worldwide calorie availability, and by 2050 increase child malnutrition by 20%.[331] Climate change threatens global food security and so any effort to mitigate global warming is effectively promoting a secure food supply.[332]

8. Human Health Impacts

Combustion of fossil fuels and resulting climate change are already contributing to an increase in asthma, cancer, cardiovascular disease, stroke, heat-related morbidity and mortality, food-borne diseases, and neurological diseases and disorders.[333] Climate change has been called "the most serious threat to the public health of the 21st century."[334] Droughts, floods, heat waves and other extreme weather events linked to climate change also lead to a myriad of health issues.[335] The World Health Organization has stated that "[l]ong-term climate change threatens to exacerbate today's problems while undermining tomorrow's health systems, infrastructure, social protection systems, and supplies of food, water, and other ecosystem products and services that are vital for human health."[336] Climate change is not only expected to affect the basic requirements for maintaining health (clean air and water, sufficient food, and adequate shelter) but it is likely to present new challenges for controlling infectious disease and even "halt or reverse the progress that the global public health community is now making against many of these diseases."[337] Children are especially vulnerable to adverse health impacts due to climate change.[338]

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[329] USCCSP & USDA, *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity, in Synthesis and Assessment Product 4.3*, 59 (May 2008), http://www.usda.gov/oce/climate_change/SAP4_3/CCSPFinalReport.pdf ("Many weeds respond more positively to increasing CO_2 than most cash crops . . . . Recent research also suggests that glyphosate, the most widely used herbicide in the United States, loses its efficacy on weeds grown at CO_2 levels that likely will occur in the coming decades.").

[330] Nelson, eta l., Int'l Food Policy Research Inst., *Food Policy Report: Climate Change- Impacts on Agriculture and Costs of Adaptation*, vii (Oct. 2009), http://www.fao.org/fileadmin/user_upload/rome2007/docs/Impact_on_Agriculture_and_Costs_of_Adaptation.pdf.

[331] *Id.*

[332] *Id.* at ix ("Climate change will pose huge challenges to food-security efforts. Hence, any activity that supports agricultural adaptation also enhances food security.").

[333] *See* Center for Health and the Global Environment, Harvard Medical School, *Climate Change Futures: Health, Ecological, and Economic Dimensions* (Nov. 2005), http://ccsl.iccip.net/ccf_report_oct_06.pdf; USGCRP, *Climate Change Impacts*, *supra* note 118, at 221–28.

[334] Casey Crandell, *Climate Action Holds Potential for Massive Improvements in Public Health,* PHYSICIANS FOR SOCIAL RESPONSIBILITY (June 22, 2015), http://www.psr.org/blog/climate-action-holds-potential-improvements-public-health html.

[335] *Id.*

[336] World Health Organization, *Atlas of Health and Climate*, 4 (Oct. 2012), http://www.who.int/globalchange/publications/atlas/report/en.

[337] World Health Organization, *Protecting Health from Climate Change: Connecting Science, Policy, and People*, 2 (2009), http://www.who.int/globalchange/publications/reports/9789241598880/en/index.html.

[338] *Id.* at 2, 6, 11–12, 16–17.

Recent studies have highlighted the adverse mental health effects that result from climate change. One study noted that as many as 200 million Americans are expected to have mental health problems as a result of climate change and added that mental health disorders are likely to be one of the most dangerous indirect health effects of climate change.[339] The mental health effects can include elevated levels of anxiety, depression, PTSD, and a distressing sense of loss.[340] The impacts of these mental health effects include chronic depression, increased incidences of suicide, substance abuse, and greater social disruptions like increased violence.[341]

9. National Security and Global Politics

The changing climate also raises national security concerns, as "climate change will add to tensions even in stable regions of the world."[342] The U.S. Department of Defense has acknowledged the severity of climate change and its connections to national security.[343] The Quadrennial Defense Review classified climate change as a "threat multiplier."[344] Specifically, "Pentagon leaders have identified three main ways that climate change will affect security: accelerating instability in parts of the world wracked by drought, famine, and climate-related migrations; threatening U.S. military bases in arid Western states or on vulnerable coastlines; and increasing the need for U.S. forces to respond to major humanitarian disasters."[345] The United States may experience an additional need to accept immigrant and refugee populations as droughts increase and food production declines in other countries.[346] Increased extreme weather events (such as hurricanes) will also present an increased strain on foreign aid and call for military forces.[347] For instance, by 2025, 40% of the world's population will be living in countries experiencing significant water shortages, while sea-level rise could cause displacement of tens, or even hundreds, of millions of people.[348]

B. Climate Change is Already Occurring in the State of Alaska and Will Continue to Significantly Impact the State in the Future.

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[339] Kevin Coyle, and Lise Van Susteren, *The Psychological Effects of Global Warming on the United States: And Why the U.S. Mental Health Care System is not Adequately Prepared*, NAT. WILDLIFE FED'N. CLIMATE EDUCATION REPORT (Feb. 2012), https://www.nwf.org/~/media/PDFs/ Global-Warming/Reports/Psych_Effects_Climate_Change_Full_3_23.ashx.
[340] *Id.* at 7.
[341] Nick Watts, et al., *Health and Climate Change: Policy Responses to Protect Public Health*, LANCET (June 23, 2015), http://thelancet.com/journals/lancet/article/PIIS0140-6736(15)60854-6/abstract.
[342] The CNA Corp., *National Security and the Threat of Climate Change* 7 (2007), https://www.cna.org/cna_files/pdf/national%20security%20and%20the%20threat%20of%20climate%20change.pdf; *see also* CNA Military Advisory Board, *National Security and the Accelerating Risks of Climate Change* (2014), https://www.cna.org/cna_files/pdf/MAB_5-8-14.pdf.
[343] Keith Johnson, *A Clear and Present Danger*, FOREIGN POLICY 3 (May 6, 2014), http://www.foreignpolicy.com/articles/2014/05/06/a_clear_and_present_danger ("Environmental issues, energy issues - they are all connected, and they are all integrated into our national security.").
[344] Thompson, *Climate Change: The Evidence and Our Options, supra* note 244, at 3.
[345] *Id.*
[346] The CNA Corp., *National Security and the Threat of Climate Change, supra* note 342, at 7.
[347] *Id.*
[348] *Id.* at 16.

"*There is little doubt that Alaskans are feeling the effects of climate change more than anyone else in our nation. Regardless of whether these changes are caused solely by human activity, we must take steps to protect people in the Arctic*."
~ Senator Ted Stevens, July 11, 2007[349]

The State of Alaska has become an example of what the world might look like if it continues to warm: "Alaska is a bellwether for climate change: It's where we look to see the earliest indicators of where the rest of the planet will be shortly."[350] Due to the state's size, location, and diverse ecosystems, Alaska has experienced some of the most substantial impacts of climate change.[351] The effects of global warming in Alaska are significant, varied, and interrelated, impacting surface and water temperatures, sea ice, glaciers, permafrost, forests, agriculture, wildfires, ocean acidification, fish, wildlife, and human health.[352] As former Governor Sarah Palin stated, "Climate change is not just an environmental issue. It is also a social, cultural, and economic issue important to all Alaskans."[353]

1. Alaska Is On the Front Lines and Has Already Experienced Significant and Rapid Warming

Average annual temperatures in Alaska and the Arctic have "risen almost twice the rate as the rest of the world in the past few decades."[354] Alaska's average annual temperatures have increased 2-3 °C since the 1950's, and as high as 6 °C in the winter, with "substantial year-to-year and regional variability."[355] According to the National Oceanic and Atmospheric Administration (NOAA), Alaska was as high as "*eleven* degrees [Fahrenheit] over the

[349] Alaska Climate Impact Assessment Commission, Final Commission Report, 3 (March 17, 2008), https://climatechange.alaska.gov/aag/docs/O97F17502.pdf.
[350] Ria Misra, *Alaska is on Track for an Absurdly Hot Year*, GIZMODO (May 6, 2016), http://gizmodo.com/alaska-is-on-track-for-an-absurdly-hot-year-1775179194.
[351] *Id*.
[352] *See* U.S. Global Change Research Program, *Alaska: Regional Highlights from the Third National Climate Assessment* (2014), http://www.globalchange.gov/sites/globalchange/files/Regional_AK_V2.pdf.
[353] *See* State of Alaska Administrative Order No. 238, September 17, 2007, http://www.gov.state.ak.us/admin-orders/238 html [hereinafter "Order 238" or "the Order"]; *infra* section VI.
[354] Susan Joy Hassol, ACIA, *Impacts of a Warming Arctic: Arctic Climate Impact Assessment*, 14 (2004), http://www.acia.uaf.edu/pages/overview html; *see also* U.S. Department of the Interior, U.S. Geological Study, *Baseline and Projected Future Carbon Storage and Greenhouse Gas Fluxes in Ecosystems in Alaska*, 17 (2016), https://pubs.er.usgs.gov/publication/pp1826*; see also* U.S. Environmental Protection Agency, *Climate Impacts in Alaska* (Jan. 19, 2017), https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-alaska_.html; *see also Alaska: Climate Change Ground Zero*, CLIMATE NEXUS (2015), http://climatenexus.org/learn/regional-impacts/alaska-climate-change-ground-zero; *see also* Megan Gannon, *Arctic is Heating up Twice as Quickly as Rest of World*, LIVE SCIENCE (Dec. 17, 2014), http://www.livescience.com/49172-arctic-heats-up-twice-as-quickly.html; *see also* Cindy Shogan, *Big Oil makes a push for risky and reckless Arctic drilling*, THE HILL (July 18, 2016), http://thehill.com/blogs/congress-blog/energy-environment/288073-big-oil-makes-a-push-for-risky-and-reckless-arctic.
[355] F. Stuart Chapin, & Sarah F. Trainor, *Climate Change Impacts in the United States: The Third National Climate Assessment: Chapter 22: Alaska*, US GLOBAL CHANGE RESEARCH PROGRAM 514–36, 516 (2014), http://www.cakex.org/sites/default/files/documents/NCA3_Full_Report_22_Alaska_LowRes.pdf.; *see also* Yereth Rosen, *What Climate Change looks Like in Alaska Now*, ALASKA DISPATCH NEWS (Aug. 29, 2015), http://www.adn.com/environment/article/alaska-climate-story/2015/08/29.

[temperature] norm in 2016."[356] Recent findings by the Alaska Climate Research Center show an increase in average annual winter temperature for the state from 1949 to 2016 of 6.7 degrees Fahrenheit, with increases as high as 9.9 degrees in some areas.[357] "As the climate continues to warm, average annual temperatures are projected to increase an additional 2 to 4°F by the middle of this century."[358]

Less three years ago, in 2014, Alaskans experienced the warmest year on record since the 1920's.[359] NOAA's ESRL 20th Century Reanalysis, which constructs a global climate history going back to 1871, "show[ed] no year in that time period [from 1871] as warm as 2014 for Alaska."[360] According to the National Weather Service in Alaska, a number of cities across the state found 2014 was their warmest year on record as well.[361] The warming trend continued unabated in 2015 with many cities, including Juneau, again experiencing record-breaking annual temperatures.[362] In July of 2015, Juneau had just recently "finished its ninth consecutive month of warmer-than-normal temperatures and [was] on pace for its warmest year on record."[363] Indeed, Juneau's warmer-than-normal 2015 temperatures continued not only for Juneau (resulting in record low snowfall in January 2016),[364] but for the state as a whole. Alaska again experienced unprecedented warming in 2016, "shattering average temperature records that in some cases have been kept for more than a century."[365] As in the previous year, many communities experienced their highest average temperature ever with many not only breaking previous records, but doing so by "huge margins."[366] In the 2015-2016 winter, "for the first winter in the historical record, no community in Alaska reached a low of -50°F."[367] Because of warm weather and associated lack of snowfall organizers of the Iditarod sled dog race "had to cart in snow" from Fairbanks; the previous year they had to move the race 200 miles north due to warm weather and lack of snow.[368] Tellingly, 2016 marked the first year that Nome's average

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[356] Misra, *supra* note 350; *see also* James Brooks, *Juneau on Pace for Warmest Year Ever, Beating Last Year's Warmest Year Ever*, JUNEAU EMPIRE (July 7, 2016), http://juneauempire.com/local/2016-07-06/juneau-pace-warmest-year-ever-beating-last-years-warmest-year-ever.
[357] Alaska Climate Research Center, *Temperature Changes in Alaska*, http://climate.gi.alaska.edu/ClimTrends/Change/TempChange.html.
[358] U.S. Environmental Protection Agency, *Climate Impacts in Alaska*, supra note 354.
[359] Teresa Sundmark, *Spring Came Too Early in Alaska*, ALBUQUERQUE J. (June 24, 2016), http://www.abqjournal.com/797262/spring-came-too-early-in-alaska.html; *see also* Brian Brettschneider, *2014 was Warmest Year on Record for Much of Alaska,* ALASKA DISPATCH NEWS (January 5, 2015), http://www.adn.com/weather/article/indications-suggest-2014-will-go-down-warmest-year-record-some-alaska-locales/2015/01/06.
[360] Brettschneider, *supra* note 359.
[361] *Id*.
[362] James Brooks, *Juneau on Pace for Warmest Year Ever, Beating Last Year's Warmest Year Ever*, JUNEAU EMPIRE (July 7, 2016), http://juneauempire.com/local/2016-07-06/juneau-pace-warmest-year-ever-beating-last-years-warmest-year-ever.
[363] *Id*.
[364] *Id*.
[365] Audrey Rubel & Rick Thoman, NOAA, *2016 Shatters Record for Alaska's Warmest Year* (Jan. 10, 2017), https://www.climate.gov/news-features/features/2016-shatters-record-alaskas-warmest-year.
[366] *Id*.
[367] Tom Di Liberto, *Where, Oh Where, Has Alaska's Winter Gone?*, NOAA (March 11, 2016), https://www.climate.gov/news-features/event-tracker/where-oh-where-has-alaska's-winter-gone.
[368] *Id*.

annual temperature was above freezing.[369] Further, according to Alaska-based climatologist, Brian Brettschneider, in summer of 2016 Deadhorse reached a record high of 85 degrees, which is now the "hottest temperature on record anywhere in the state within 50 miles of the Arctic Ocean."[370] When such warming happens, the state can change "sweepingly and systematically."[371]

Indeed, this warming has caused frozen rivers to break up earlier than before, shifted the growing season earlier than before, practically caused a statewide drought,[372] melted sea ice and permafrost,[373] influenced seasonal migration of birds and other animals, altered the habitats of both ecologically important and endangered species, and affected ocean currents.[374] Dubbed the "Arctic Amplification," these warmer temperatures also feed a loop, creating further global warming through a "self-reinforcing process that warms the Arctic and subarctic far faster than the rest of the world."[375] When "bright and reflective ice melts," the ocean darkens, and in the process "amplifies the warming trend because the ocean surface absorbs more heat from the Sun than the surface of snow and ice."[376] In other words, a reduction of sea ice also reduces Earth's albedo: "the lower the albedo, the more a surface absorbs heat from sunlight rather than reflecting it back to space."[377] Additionally, warming in Alaska links to "extreme weather events in the rest of the world."[378]

2. Temperatures in Alaska are Projected to Continue to Increase

Temperatures in Alaska are projected to increase by an additional 2°F to 4°F by 2050 and "as much as 8 degrees Celsius in the Arctic and Western Alaska Landscape Conservation Cooperatives (LCCs) by the end of this century."[379] According to the Arctic Climate Impact Assessment, temperatures could increase up to "3-5°C over the land areas and up to 7°C over the

[369] Audrey Rubel & Rick Thoman, NOAA, *2016 Shatters Record for Alaska's Warmest Year* (Jan. 10, 2017), https://www.climate.gov/news-features/features/2016-shatters-record-alaskas-warmest-year.
[370] Jon Erdman, *Deadhorse, Alaska, Sets State Record High For Any Arctic Ocean Location*, WEATHER CHANNEL (July 15, 2016), https://weather.com/news/climate/news/deadhorse-alaska-record-high-arctic-ocean-july2016.
[371] Chris Mooney, *5 Ways Climate Change is Already Affecting Alaska*, CHICAGO TRIBUNE (August 31, 2015), http://www.chicagotribune.com/news/nationworld/ct-alaska-climate-change-20150831-story html.
[372] Misra, *supra* note 350.
[373] Daniel Cordalis & Dean B. Suagee, *The Effects of Climate Change on American Indian and Alaska Native Tribes*, 22 NAT. RESOURCES & ENV'T 45, 47 (2008), https://www.americanbar.org/content/dam/aba/publications/natural_resources_environment/2008_winter/nre_win08_cordalis_suagee.authcheckdam.pdf.
[374] Hezel, P. J. et al., *Projected Decline in Spring Snow Depth on Arctic Sea Ice Caused by Progressively Later Autumn Open Ocean Freeze-Up this Century*, GEOPHYSICAL RESEARCH LETTERS 39 (Sept. 15, 2012) L17505, available at http://onlinelibrary.wiley.com/doi/10.1029/2012GL052794/epdf.
[375] Rosen, *supra* note 355.
[376] *Arctic Amplification: Image of the Day*, NASA EARTH OBSERVATORY (2009), http://earthobservatory.nasa.gov/IOTD/view.php?id=81214.
[377] *Id*.
[378] Rosen, *supra* note 355.
[379] U.S. Department of the Interior, U.S. Geological Study, *Baseline and Projected Future Carbon Storage and Greenhouse Gas Fluxes in Ecosystems in Alaska*, *supra* note 354; *see also* Chapin, *supra* note 355, at 516; *see also* Scenarios Network for Alaska + Arctic Planning ("SNAP"), *Climate Projections Map Analysis Tool*, https://www.snap.uaf.edu/sites/all/modules/snap_map_tool/maps.html.

oceans."[380] Further, winter temperatures are expected to increase significantly more, up to "4-7°C over the land areas and 7-10°C over the oceans."[381] Increased temperatures will cause more extreme impacts across the State of Alaska, as well as the rest of the world.

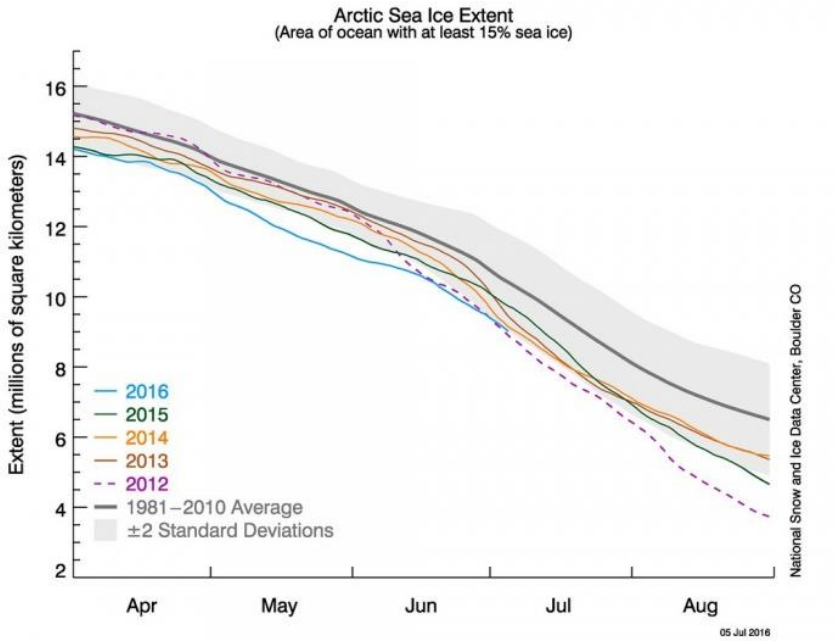
3. Biosphere Impacts

(a) Melting Sea Ice

Climate change has impacted both the "extent and thickness of Arctic sea ice," so much so that "the past seven years [2007-2014] have seen the lowest sea ice extents ever recorded."[382] In fact, by 2014, Arctic sea ice cover had declined by 50 percent from the beginning of satellite records in 1979.[383] This means that an expanse of sea ice, about twice the size of Texas, "has vanished over the past 30 years, and the rate of that retreat has accelerated."[384] The volume of late summer arctic sea ice is now estimated to be only "one-fifth of what it was in 1980," when modeling data began.[385] 2016 continued this trend, bringing some of the most extreme reductions in sea ice seen to date. According to the National Snow & Ice Data Center, June 2016 averaged the "lowest [sea ice extent] in the satellite record for the month."[386] The sea ice extent in June 2016 was 100,000 square miles below the 2010 record low, and 1.36 million square kilometers "below the 1981 to 2010 long-term average."[387] In fact, the past three years have shown consecutively new record lows for maximum extent arctic sea ice[388], demonstrating accelerating losses as the earth warms. Figures 2 and 3 illustrate the alarming trend in annual loss of sea ice.[389]

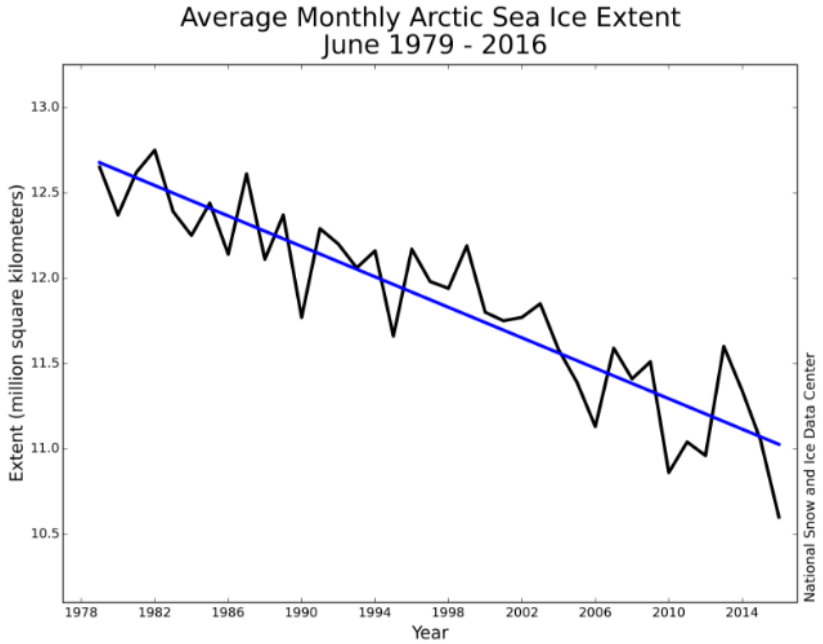
Figure 2:

[380] Hassol, *supra* note 354, at 28.
[381] *Id.*
[382] *Alaska: Climate Change Ground Zero*, *supra* note 354.
[383] Chapin, *supra* note 355, at 516.
[384] Suzanne Goldenberg, *Arctic Sea Ice Crashes to Record Low for June*, GUARDIAN (July 7, 2016), https://www.theguardian.com/environment/2016/jul/07/arctic-sea-ice-crashes-to-record-low-for-june.
[385] Hannah Hickey, *European Satelite Confirms UW Numbers: Arctic Ocean is On Thin Ice*, UW TODAY (Feb. 13, 2013), http://www.washington.edu/news/2013/02/13/european-satellite-confirms-uw-numbers-arctic-ocean-is-on-thin-ice.
[386] U.S. National Snow and Ice Data Center, *Extent Loss Slows, Then Merges Back into Fast Lane* (July 6, 2016), http://nsidc.org/arcticseaicenews/2016/07/extent-loss-slows-then-merges-back-into-fast-lane.
[387] *Id.*
[388] NASA, *2015 Arctic Sea Ice Maximum Annual Extent Is Lowest On Record* (Mar. 19, 2015), https://www.nasa.gov/content/goddard/2015-arctic-sea-ice-maximum-annual-extent-is-lowest-on-record; NASA, *2016 Arctic Sea Ice Wintertime Extent Hits Another Record Low*, (Mar. 28, 2016), http://www.nasa.gov/feature/goddard/2016/2016-arctic-sea-ice-wintertime-extent-hits-another-record-low; NASA, *Sea Ice Extent Sinks to Record Lows at Both Poles* (March 22, 2017), https://www.nasa.gov/feature/goddard/2017/sea-ice-extent-sinks-to-record-lows-at-both-poles.
[389] U.S. NATIONAL SNOW & ICE DATA CENTER, *Extent Loss Slows, Then Merges Back into Fast Lane* (July 6, 2016), http://nsidc.org/arcticseaicenews/2016/07/extent-loss-slows-then-merges-back-into-fast-lane.



[390]

Figure 3:



[391]

Such rapid sea ice loss is "primarily a result of rising temperatures,"[392] and further amplifies global warming.[393] Usually, sea ice acts as a shield between the Arctic Ocean and the

[390] *Id.*
[391] *Id.*
[392] Chapin, *supra* note 355, at 519.
[393] *Alaska: Climate Change Ground Zero*, *supra* note 354.

atmosphere, and prevents the ocean from absorbing the Sun's energy.[394] But, as the sea ice melts, "there is more open ocean to absorb this energy."[395] The additional heat in the ocean leads to more melting ice, which further allows the ocean water to absorb even more heat.[396] Because "polar ice caps help to regulate global temperature by reflecting sunlight back into space," Arctic sea ice plays an important role in the global climate system.[397]

Increased temperatures as well as sea ice loss have already started to influence "atmospheric circulation and patterns of precipitation."[398] Further, ice loss has devastating consequences for polar bears, ice-dependent seals, walruses, and the Alaska Natives for whom these animals are a primary food source.[399] As sea ice declines, populations of seals are projected to decline, which results in smaller polar bears, which prey on seals as a primary food source.[400] Further, it is estimated that sea ice loss will result in "a loss of 2/3 of the polar bear population, and force the remaining bears into a smaller, iceless area."[401] Ice loss has also caused a threshold change in walrus ecology, as walrus depend on sea ice "as a platform for giving birth, nursing, and resting between dives to the seafloor, where they feed."[402] This ice loss force walruses to live ashore, causing "increased competition for food and . . . stampedes when animals are startled, resulting in trampling of calves."[403] As sea ice melts its accumulates less build-up and is thus "more vulnerable to further melting,"[404] further exacerbating the problems caused to wildlife and humans alike by loss of sea ice. Ice loss has also resulted in flooding and erosion of coastal villages.[405] Further, loss of sea ice exposes coastal villages to increased destruction from high energy storms.[406]

Further increase in temperatures is projected to melt the remaining arctic sea ice by the 2030's,[407] which will carry enormous environmental, economic, and social implications.[408]

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[394] *Id.*
[395] *Id.*
[396] *Id.*
[397] *Arctic Sea Ice Decline*, Weather Underground, https://www.wunderground.com/climate/SeaIce.
[398] Chapin, *supra* note 355, at 517.
[399] *See id.*
[400] *Id.* at 518; *see also* Margie Ann Gibson & Sallie B. Schullinger, *Answers from the Ice Edge: The Consequences of Climate Change on Life in the Bering and Chukchi Seas,* Greenpeace U.S.A. (1998), https://www.greenpeace.de/sites/www.greenpeace.de/files/answersfrom_icedge_0.pdf.
[401] *Arctic Sea Ice Decline*, *supra* note 397.
[402] Chapin, *supra* note 355, at 517.
[403] *Id.*
[404] *Id.*
[405] *Arctic Sea Ice Decline*, *supra* note 397.
[406] A. I. Gould et al., *Guide to Projected Shoreline Positions in the Alaska Shoreline Change Tool*, ALASKA DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS MISC PUB 158 (2015) http://pubs.dggsalaskagov.us/webpubs/dggs/mp/text/mp158.pdf.
[407] Chapin, *supra* note 355; *see also* John Vidal, *Arctic Expert Predicts Final Collapse of Sea Ice within Four Years*, GUARDIAN (Sept. 17, 2012), https://www.theguardian.com/environment/2012/sep/17/arctic-collapse-sea-ice; *see also Arctic Sea Ice Decline*, *supra* note 397.
[408] Yereth Rosen, *Warming Climate Disrupts Alaska Natives' Lives*, GLOBAL CORAL REEF ALLIANCE (April 16, 2004 http://www.globalcoral.org/_oldgcra/Warming%20Climate%20Disrupts%20Alaska%20Natives'%20Lives.htm; *see also* D. Notz & J Stroeve, *Observed Arctic Sea-Ice Loss Directly Follows Anthropogenic CO2 Emission*, SCIENCE (Nov. 3, 2016), aag2345, DOI: 10.1126/science.aag2345.

Impacts of an ice-free Arctic "could be a trigger for abrupt, cataclysmic climate change in the future" to both local Alaskan and global environments.[409] Continued sea ice decline will result in more extreme weather patterns, a decline in marine life populations, flooding and erosion.

(b) Melting Glaciers

Although Alaska has some of the world's largest glaciers, it is also home to the "fastest loss of glacier ice on Earth," which is "primarily a result from rising temperatures."[410] Alaska's mountain glaciers hold "1 percent of the world's glacial ice."[411] However, the rapid loss of Alaska's glaciers have accounted for "nearly one third of the current observed sea level rise."[412] Melted glaciers from around the world "contributed as much to global sea rise as the Greenland and Antarctic ice sheets combined from 2003 to 2009."[413] The data shows that the loss of glacial ice is only accelerating as climate change continues unabated. In early 2012, data revealed that Alaska's glaciers were melting at the rate of 46 billion tons of ice per year.[414] Only three years later, scientists at the University of Alaska Fairbanks found that Alaska's glaciers were then losing "75 billion tons of ice a year."[415] Roughly 20% of glacial mass in Lake Clark National Park and Preserve was lost between 1987 and 2007 alone.[416]

Because warming temperatures have led to a decline in snow deposition on glaciers, "[t]he majority of glaciers in Southeast Alaska are thought to be retreating."[417] A 2015 study by the U.S. Fish and Wildlife Service found that 9% of the 109 mapped glaciers in the Ahklun Mountains of southwestern Alaska had already disappeared.[418] The study concluded that at this

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[409] *Arctic Sea Ice Decline*, *supra* note 397.
[410] Chapin, *supra* note 355, at 519; *see also Alaska: Climate Change Ground Zero*, *supra* note 397.
[411] Rosen, *supra* note 355; *see also Alaska: Climate Change Ground Zero*, *supra* note 397.
[412] Chapin, *supra* note 355; *see also Alaska: Climate Change Ground Zero*, *supra* note 397; *see also* Rosen, *supra* note 355.
[413] *Alaska: Climate Change Ground Zero*, *supra* note 397.
[414] Doug O'Harra, *Alaska Glaciers Losing 46 Billion Tons of Ice Each Year*, ALASKA DISPATCH NEWS (Feb. 12, 2012), https://www.adn.com/science/article/alaska-glaciers-losing-46-billion-tons-ice-each-year/2012/02/13; *Graphic: Dramatic Ice Melt*, NASA (last updated August 15, 2017), http://climate nasa.gov/climate_resources/4 ("Forty-six gigatons of ice from Alaskan glaciers was lost on average each year from 2003 to 2010.").
[415] C.F. Larson, et al., *Surface Melt Dominates Alaska Glacier Mass Balance*, 42 GEOPHYS RES. LETT. 5902–08 (2015), http://onlinelibrary.wiley.com/doi/10.1002/2015GL064349/full; *see also* Rosen, *supra* note 355; *see also* Yereth Rosen, *Remnant Glaciers in Western Alaska Expected to Disappear by Century's End,* ALASKA DISPATCH NEWS (Feb. 7, 2015), http://www.adn.com/science/article/remant-glaciers-western-alaska-are-expected-disappear-centurys-end/2015/02/07; *see also* Mooney, *supra* note 371; *see also* Michael Casey, *Alaska Glaciers Sending 75 Billion Tons of Water into Sea Each Year*, CBS NEWS (June 18, 2015), http://www.cbsnews.com/news/alaska-glaciers-sending-75-billion-tons-of-water-into-sea-each-year.
[416] C. Moore, D. Young, J. Shearer, *Evaluating Effects of Atmospheric and Terrestrial Disturbance in a Southwest Alaska Lake*, NATIONAL PARK SERVICE, SOUTHWEST ALASKA NETWORK (2014), https://science.nature nps.gov/im/units/swan/assets/docs/reports/presentations/Symposium2011/posters/CMoore_SWAN_AtmGeoDistLakes_SWAK_20111101.pdf.
[417] J.E. Cherry, et al., *Impacts of Climate Change and Variability on Hydropower in Southeast Alaska: Planning for a Robust Energy Future*, NOAA FISHERIES 21 (2010), https://alaskafisheries noaa.gov/sites/default/files/ccv_hydro_se.pdf.
[418] Patrick Walsh et al., *Historical Retreat of Alpine Glaciers in the Ahklun Mountains, Western Alaska*, U.S. FISH AND WILDLIFE MANAGEMENT (2015), http://www fwspubs.org/doi/10.3996/012014-JFWM-008?code=ufws-site#_i8.

melting rate, all of the Ahklun glaciers will be "extinguished by the end of the current century.[419] For example, the Columbia Glacier has lost "about half its total thickness and volume" since the 1980's.[420] By 2014, the glacier had retreated more than 20 kilometers to the north.[421] The glacier will likely retreat an additional 13 kilometers by 2030.[422] Additionally, Bear Glacier, pictured below, has also dramatically retreated two miles from 2000 to 2007, compared to a retreat of one mile from 1950's to 1990's.[423]

[424]

Additionally, as of 2005, Muir Glacier, pictured below, had retreated more than 50 kilometers, which meant that the glacier was "no longer visible."[425]

[419] *Id.*
[420] Adam Volland, *Columbia Glacier, Alaska*, NASA (July 2, 2014), https://earthobservatory nasa.gov/Features/WorldOfChange/columbia_glacier.php.
[421] *Id.*
[422] *Id.*
[423] Kate Zerrenner, *Is Alaska, Another Oil State, the Next Frontier for Climate Action?*, ENVIRONMENTAL DEFENSE FUND (June 28, 2016), https://www.edf.org/blog/2016/06/28/alaska-another-oil-state-next-frontier-climate-action.
[424] Mauri Pelto, *Bear Glacier, Kenai Alaska Recedes, New Lake Formed*, AMERICAN GEOPHYSICAL UNION (Aug. 28, 2010), http://blogs.agu.org/fromaglaciersperspective/2010/08/28/bear-glacier-kenai-alaska-recedes-new-lake-formed.
[425] *Repeat Photography of Alaskan Glaciers*, USGS (last modified May 30, 2012), https://www2.usgs.gov/climate_landuse/glaciers/repeat_photography.asp.

[426]

Retreating glaciers have led to rising sea levels, and changes to marine salinity, currents, and ocean circulation,[427] flooding, and even landslides. In July 2016, part of a 6,500 foot high peak gave way on the west side of Lamplugh Glacier, located in Glacier Bay National Park.[428] An estimate from the "Lamont-Doherty Earth Observatory suggested the slide involved more than 132 million tons of material," and produced tremors registering 5.5 on the Richter scale.[429] As warming causes more glacial melt, increased landslides are likely continue.[430]

Glacial melt resulting from anthropogenic climate change also has profound impacts on freshwater and marine aquatic resources, including river systems, with associated resulting impacts to wildlife, ecology, drinking water, fisheries, and downstream hydrologic resources. In mid-2016, "the retreat of a very large glacier in Canada's Yukon territory led to the rerouting of its vast stream of meltwater from one river system to another – cutting down flow to the Yukon's largest lake, and channeling freshwater to the Pacific Ocean south of Alaska, rather than to the Bering Sea."[431] Scientists estimate that the changes to these river systems is irreversible.[432] Glacial melt carries 'rock flour,' the remains of bedrock ground up by the glacier. This material is rich in minerals like iron, which, when deposited in the Gulf of Alaska, promotes phytoplankton growth. Dust also carries iron to ocean waters; visible plumes of dust from the

[426] *Muir Glacier*, U.S. National Snow and Ice Data Center, https://nsidc.org/arc/adopt-a-glacier/muir.html.
[427] David Stauth, *Massive Amounts of Fresh Water, Glacial Melt Pouring into the Gulf of Alaska*, OREGON STATE UNIVERSITY (Mar. 19, 2015), http://oregonstate.edu/ua/ncs/archives/2015/mar/massive-amounts-fresh-water-glacial-melt-pouring-gulf-alaska.
[428] Henry Fountain, *As Glaciers Melt in Alaska, Landslides Follow*, N.Y. TIMES (July 5, 2016), http://www.nytimes.com/2016/07/06/science/alaska-landslides-glaciers-melt html.
[429] *Id.*
[430] *Id.*
[431] Chris Mooney, *For the First Time on Record, Human-caused Climate Change Has Rerouted an Entire River*, WASHINGTON POST (Apr. 17, 2017), https://www.washingtonpost.com/news/energy-environment/wp/2017/04/17/for-the-first-time-on-record-human-caused-climate-change-has-rerouted-an-entire-river.
[432] *Id.*

Kenai Peninsula to Yakatat have been captured by NOAA satellites.[433] Glacier melt in Alaska is also likely to expose the sulfide-bearing rock abundant throughout the state;[434] exposure of such minerals combined with precipitation can lead to stream pH and trace metals concentrations "comparable to acid mine drainage."[435] Glacier melt in Alaska has profound impacts on countless natural systems: it affects downstream biological communities such as salmon and herring; it changes freshwater inputs to streams; it drives the Alaska Coastal Current that moves heat, nutrients, and organisms northward, providing the basis for Alaska fisheries; it carries organic materials and metals that boost phytoplankton; and it releases mercury and other contaminants deposited from the atmosphere onto glaciers.[436] As a result of these and other connections between glaciers and Alaska's complex natural systems, the retreat and possible loss of Alaska's glaciers due to climate change has profound, cascading impacts to Alaska's natural heritage, Alaska's inhabitants, and upon the industry and tourism reliant upon those systems.

(c) Thawing Permafrost

Alaska is unique from most of the rest of the country in having permafrost, which is "frozen ground that restricts water drainage and therefore strongly influences landscape water balance and the design and maintenance of infrastructure."[437] Among other important functions, permafrost stabilizes the ground and thus "absorbs the impacts of ocean waves and protects against coastal erosion."[438] However, the buffer zone that permafrost provides is disappearing, "and without it coastal erosion could accelerate and threaten critical infrastructure."[439] "Permafrost lays underneath about 80 percent of Alaska's surface," and over 70 percent of that ice is "vulnerable to land sinkage due to the steady rate of permafrost thaw."[440]

Alaska has already started to experience the impacts of thawing permafrost. "Generally over the last 20 to 30 years, permafrost temperatures have increased 1 to 2 degrees C."[441] In fact, rising temperatures have already led to permafrost loss in Fairbanks, which has "damaged forests as well as roads, buildings, and other infrastructure."[442]In the Kenai Peninsula, permafrost has

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[433] J. Crusius, *Glacial Flour Dust Storms in the Gulf of Alaska: Hydrologic and Meteorological Controls and Their Importance as a Source of Bioavailable Iron*, 38 GEOPHYS RES. LETTERS, HTTP://ONLINELIBRARY.WILEY.COM/DOI/10.1029/2010GL046573/FULL.

[434] *See* Susan Bartsch-Winkler, Katherine M. Reed, U.S. Geological Survey, *Geologic Studies in Alaska by the U.S. Geological Survey during 1985*, U.S. GEOLOGICAL SURVEY CIRCULAR 978, http://www.fop.cascadiageo.org/alaska_cell/2006/c-0978.pdf.

[435] S.K. Fortner et al., *Elevated Stream Trace and Minor Element Concentrations in the Foreland of Receding Tropical Glaciers*, Abstract. 26 APP GEOCHEM 1792–1801.

[436] S. O'Neel et al., *Icefield-to-Ocean Linkages Across the Northern Pacific Coastal Temperate Rainforest Ecosystem*, 65 BIOSCIENCE 499–512, https://academic.oup.com/bioscience/article-lookup/doi/10.1093/biosci/biv027.

[437] Chapin, *supra* note 355, at 520.

[438] Daniel Bush, *Arctic Coastlines Threatened by Melting Permafrost*, BARENTS OBSERVER (Oct. 5, 2013), http://barentsobserver.com/en/nature/2013/10/arctic-coastlines-threatened-melting-permafrost-05-10.

[439] *Id*.

[440] Rosen, *supra* note 355; *see also* Chapin, *supra* note 355, at 520.

[441] Robert Clark, et al., *The Effects of a Changing Climate on Key Habitats in Alaska*, Special Publication No. 10-14, p. 16, ALASKA DEPT. OF FISH AND GAME (Sept. 2010), https://www.adfg.alaska.gov/static/lands/ecosystems/pdfs/sp10_14.pdf

[442] *Alaska: Climate Change Ground Zero*, *supra* note 354.

decreased by sixty percent since 1950.[443] Permafrost in the northern range, where it is thickest, has started to warm, and permafrost in the southern range has started to decline.[444] Indeed, "[p]ermafrost near the Alaskan Arctic coast has warmed 4°F to 5°F at 65 foot depth since the late 1970s and 6°F to 8°F at 3.3 foot depth since the mid-1980s.[445] These aggressive shifts in permafrost temperature have been linked to a release of more greenhouse gases, erosion of lakes, "trees toppling, roads buckling, and the development of sinkholes."[446] And this is just the beginning. According to the National Climate Assessment, "permafrost in Alaska will continue to thaw."[447] Further, near-surface permafrost is projected to be "lost entirely from large parts of Alaska by the end of the century."[448]

Permafrost has been warming in the network of shallow lakes across northern Alaska, which "play a key role in everything from habitat to how the landscape functions."[449] Thawing permafrost will impact water quality, including "turbidity, sedimentation, nutrients and other contaminants."[450] Further, as permafrost beneath forests melts, forests sink or "drown" and lead to a curious phenomenon known as "drunken trees."[451] In fact, permafrost thaw and thermokarst have resulted in the loss of entire birch forests, indicating that permafrost temperatures in ice-rich birch forests have destabilized as a result of climate change.[452] As ground surface subsides due to permafrost thaw, thermokarst terrain manifests itself as "a chaotic surface with small hills and wet depressions."[453] Thermokarst can "compromise structural integrity and can even lead to collapse," when it exists beneath a road, house, pipeline, or airfield.[454] The hard costs to repair the sinking of ground caused by permafrost thaw is "estimated to add between $3.6 and $6.1 billion (10% to 20%) to current costs of maintaining public infrastructure."[455] Indeed, melting

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[443] Shahla Farzan, *Researchers Say Kenai Peninsula Thawing Rapidly*, ALASKA PUBLIC MEDIA (Jan. 25, 2017), http://www.alaskapublic.org/2017/01/25/researchers-say-kenai-peninsula-permafrost-thawing-rapidly; B. M. Jones et al., *Presence of Rapidly Degrading Permafrost Plateaus in South-Central Alaska*, 10 CRYOSPHERE 2673–92 (2016), https://www.the-cryosphere.net/10/2673/2016/tc-10-2673-2016.pdf.

[444] Rosen, *supra* note 355; *see also Alaska: Climate Change Ground Zero*, *supra* note 354; *see also* Matt McGrath, *Permafrost warming in parts of Alaska 'is accelerating'*, BBC News (October 22, 2015), *available at* http://www.bbc.com/news/science-environment-34540414.

[445] Chapin, *supra* note 355, at 520.

[446] McGrath, *supra* note 444.

[447] Chapin, *supra* note 355, at 520.

[448] *Id.*; *see also Alaska: Climate Change Ground Zero*, *supra* note 354.

[449] Eilis Quinn, *What Shallow Lakes are Telling Us About Changing Arctic Climate*, RADIO CANADA INTERNATIONAL (July 8, 2016), http://www.rcinet.ca/en/2016/07/08/what-shallow-lakes-are-telling-us-about-the-changing-arctic-climate.

[450] Alaska Department of Environmental Conservation, *Presentation to Alaska Climate Impact Assessment Commission* (January 24, 2007), https://dec.alaska.gov/air/doc/aciac_jan07-1pg-c.pdf.

[451] *5 Ways Climate Change is Already Affecting Alaska*, *supra* note 371.

[452] M. J. Lara et al., *Thermokarst Rates Intensify Due to Climate Change and Forest Fragmentation in an Alaskan Boreal Forest Lowland*, 22 GLOBAL CHANGE BIOLOGY 816–29 (2015), available for download at https://www.researchgate net/publication/282872767_Thermokarst_rates_intensify_due_to_climate_change_and_forest_fragmentation_in_an_Alaskan_boreal_forest_lowland.

[453] U.S. Arctic Research Commission Permafrost Task Force Report, *Climate Change, Permafrost, and Impacts on Civil Infrastructure*, 8 (Dr. Frederick E. Nelson & Dr. Lawson W. Brigham, lead authors and eds., 2003), https://storage.googleapis.com/arcticgov-static/publications/other/permafrost.pdf.

[454] *Id.*

[455] Chapin, *supra* note 355, at 520; *see also* M. K. Raynolds et al., *Cumulative Geoecological Effects of 62 Years of Infrastructure and Climate Change in Ice-Rich Permafrost Landscapes, Prudhoe Bay Oilfield, Alaska*, 20 GLOBAL

permafrost threatens many of Alaska's roadways, including the Alaska Highway, the "critical artery" between Alaska and the contiguous United States.[456] Impacts of thawing permafrost on the highway system represent "the biggest geotechnical problem" faced by Alaska's Department of Transportation.[457]

Thawing permafrost in Alaska could also have dire effects on wildlife, drastically altering habitat.[458] "Permafrost underlies most of the Arctic Network and affects nearly everything in the arctic ecosystem, from soils and vegetation to water and wildlife."[459] The continuing drying of Alaska's lakes and wetlands, "due to a combination of permafrost thaw, greater evaporation in a warmer climate, and increased soil organic accumulation," is likely to affect wildlife nationally, particularly waterfowl, "because Alaska accounts for 81% of the National Wildlife Refuge System."[460] Melting permafrost is "projected to increase nutrient, sediment, and carbon loading in river and lake systems"[461] with associated impacts on Alaska's aquatic wildlife.

Thawing permafrost will impact Alaskans in ways unimaginable. The world is already seeing some unthinkable effects of thawing permafrost. For example, in 2016, thousands of reindeer died and scores of humans were forced into quarantine in Siberia after contracting anthrax. The outbreak arose when a reindeer carcass that "died in the plague 75 years ago" thawed and "bacteria once again became active."[462] The infection "tore through the reindeer herds, [and] prompt[ed] the relocation of dozens of the indigenous Nenet community."[463] Similarly, as a result of climate change-caused ice melt, hazardous "PCBs and nuclear coolant water" from a decommissioned U.S. military base constructed underneath the Greenland Ice

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CHANGE BIOLOGY 1211–24 (2014), available for download at https://www.researchgate net/publication/259336822_Cumulative_geoecological_effects_of_62_years_of_infrastructure_and_climate_change_in_ice-rich_permafrost_landscapes_Prudhoe_Bay_Oilfield_Alaska.

[456] Greg Quinn*, Climate Change is Hell on Alaska's Formerly Frozen Highways*, BLOOMBERG (Aug. 2, 2016), https://www.bloomberg.com/news/features/2016-08-02/the-alaskan-highway-is-literally-melting.

[457] *Id*.

[458] *See* Robert Clark, et al., *The Effects of a Changing Climate on Key Habitats in Alaska*, Special Publication No. 10-14, ALASKA DEPT. OF FISH AND GAME (Sept. 2010), https://www.adfg.alaska.gov/static/lands/ecosystems/pdfs/sp10_14.pdf.

[459] National Park Service, Inventory & Monitoring, *Permafrost*, https://science.nature nps.gov/im/units/arcn/vitalsign.cfm?vsid=9.

[460] Chapin, *supra* note 355, at 520.

[461] Robert Clark, et al., *The Effects of a Changing Climate on Key Habitats in Alaska*, Special Publication No. 10-14, p. 10, ALASKA DEPT. OF FISH AND GAME (Sept. 2010), https://www.adfg.alaska.gov/static/lands/ecosystems/pdfs/sp10_14.pdf; *see also* R. C. Toohey et al., *Multidecadal Increases in the Yukon River Basin of Chemical Fluxes as Indicators of Changing Flowpaths, Groundwater, and Permafrost*, Abstract, 43 GEOPHYS RES. LETT. 1–11 (2016) ("[P]ermafrost degradation has increased the weathering of mineral soils, and deeper groundwater flow paths are occurring. The changing hydrology and water chemistry may have implications for aquatic life.").

[462] Ben Guarino, *Anthrax Sickens 13 in Western Siberia, and a Thawed-Out Reindeer Corpse May be to Blame*, WASHINGTON POST (July 28, 2016), https://www.washingtonpost.com/news/morning-mix/wp/2016/07/28/anthrax-sickens-13-in-western-siberia-and-a-thawed-out-reindeer-corpse-may-be-to-blame.

[463] *Id*.

Sheet "could begin spreading…across the surface of the ice sheet and into the ocean."[464] There is no telling what may be unearthed if Alaska's permafrost is allowed to thaw at its current rate.

However, the most significant impact of thawing permafrost is the further release of carbon dioxide and other greenhouse gases. Permafrost serves as an important carbon sink, storing large amounts of carbon, and when permafrost thaws it releases carbon dioxide into the atmosphere. Permafrost holds about 50 percent of the global soil carbon.[465] As such, rising temperatures could have grave consequences on Alaska's atmosphere due to feedback loops provided by the release of CO_2 in permafrost; as rising temperatures thaw permafrost, the released carbon dioxide causes more global warming and thus causes further thawing.[466] Rose Cory, an assistant professor in environmental sciences and engineering at the University of North Carolina explained that if all the world's permafrost thawed, "it could double the amount of heat-trapping carbon dioxide in the atmosphere."[467] Further, Cory stated that "[t]he conversion [of permafrost frozen carbon] to CO2 is going much faster than previously thought."[468] Scientists have projected that "by the year 2100, permafrost around the world…could release some 150 gigatons of carbon to the atmosphere if warming continues apace….That converts into over 500 gigatons of carbon dioxide."[469]

Sue Natali of the Woods Hole Research Center, says this feedback loop "puts even greater urgency on reducing our fossil fuel emissions now in order to avoid a future driven by an irreversible carbon feedback loop."[470] Although emitting vastly larger amounts of CO2[471], thawing permafrost also releases stores of methane, another powerful greenhouse gas, further exacerbating climate change feedback loops which could cause runaway climate change.[472] Indeed, a recent study has confirmed that climate change induced alterations have now resulted

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[464] Andrew Freedman, *Melting Warming Threatens to Unearth Waste from Secret Cold War Military Base Buried in Greenland's Ice*, MASHABLE (Aug. 4, 2016), http://mashable.com/2016/08/04/greenland-cold-war-base-global-warming-waste/#08_B68sv7Sq2.

[465] *Alaska: Climate Change Ground Zero*, *supra* note 354.

[466] E. A. G. Schuur, et al., *Climate Change and the Permafrost Carbon Feedback*, Nature 520, 171–79, 171 (April 9, 2015) https://www.researchgate net/publication/274698738_Climate_change_and_the_permafrost_carbon_feedback; *see also* Emily Atkin, *Why this New Study on Arctic Permafrost is so Scary*, Think Progress (April 8, 2015) *available at* https://thinkprogress.org/why-this-new-study-on-arctic-permafrost-is-so-scary-d0b00d0b344e/.

[467] Christa Marshall, *Melting Tundra Releases Carbon Dioxide Quickly*, Scientific American (February 13, 2012), http://www.scientificamerican.com/article/melting-tundra-releases-carbon-dioxide-quickly.

[468] *Id.*

[469] *5 Ways Climate Change is Already Affecting Alaska*, *supra* note 371.

[470] Emily Atkin, *Why this New Study on Arctic Permafrost is so Scary*, THINK PROGRESS (April 8, 2015), https://thinkprogress.org/why-this-new-study-on-arctic-permafrost-is-so-scary-d0b00d0b344e/.

[471] Christina Schnadel, et al., *Potential Carbon Emissions Dominated by Carbon Dioxide from Thawed Permafrost Soils*, 6 NATURE: CLIMATE CHANGE 950–53 (2016), https://www.researchgate net/publication/303957631_Potential_carbon_emissions_dominated_by_carbon_dioxide_from_thawed_permafrost_soils.

[472] *See* Adam Wernick, *Thawing Permafrost Could Have Catastrophic Consequences, Scientists Warn*, PUBLIC RADIO INTERNATIONAL (June 24, 2016), https://www.pri.org/stories/2015-06-24/thawing-permafrost-could-have-catastrophic-consequences-scientists-warn; K. Walter-Anthony, *Methane Emissions Proportional to Permafrost Carbon Thawed in Arctic Lakes Since the 1950s*, 9 NATURE: GEOSCIENCE 679–82 (2016).

in Alaska's arctic turning from a net carbon sink to a major carbon emissions source.[473] Scientists have warned that the "extra impacts of the permafrost" emissions "are sufficiently high to justify urgent action to minimize the scale of the" permafrost releases.[474]

4. Ecosystem Impacts

Alaska's boreal and arctic regions have "diverse and dynamic ecosystems which are sensitive to climate change."[475] According to the IPCC, the rapid rate of climate change in the Arctic "will impact natural and social systems and may exceed the rate at which some of their components can successfully adapt."[476]

(a) Wildfires and Beetles

The Alaska tundra was historically too wet and cold "to support extensive fires" for the last 5,000 years.[477] However, global warming has changed wildfire dynamics and the frequency of wildfires in Alaska. Recent tundra burning which has occurred is "unprecedented in the central Alaskan Arctic within the last 5,000 years."[478] Like melting sea ice, increased absorption of light by burned tundra relative to pre-fire conditions can influence feedback loops that accelerate and reinforce climate change.[479] The increased incidence of forest fires resulting from climate change accelerates the degradation and thawing of permafrost, among other impacts.[480]

According to Scott Rupp, a professor of forestry at the University of Alaska at Fairbanks, wildfires across the state have increased in area burned and frequency since the 1950's.[481] In

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[473] Henry Fountain, *Tundra May Be Shifting Alaska to Put Out More Carbon Than It Stores, Study Says*, N. Y. TIMES (May 8, 2017), https://www.nytimes.com/2017/05/08/climate/alaska-carbon-dioxide-co2-tundra.html; Roisin Commane, et al., *Carbon Dioxide Sources from Alaska Driven By Increasing Early Winter Respiration from Arctic Tundra*, PHYSICAL SCIENCES – EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES, PNAS 2017, published ahead of print May 8, 2017, doi: 10.1073/pnas.1618567114.

[474] C. Hope and K. Schaefer, *Economic Impacts of Carbon Dioxide and Methane Released from Thawing Permafrost*, Abstract, 6 NATURE: CLIMATE CHANGE 56–59 (2016), https://www.nacarbon.org/nacp/documents/WWR_Nov_2015_Hope.pdf.

[475] *Alaska: Climate Change Ground Zero*, *supra* note 354.

[476] Larsen, J.N., et al., *Polar regions*, *in* CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY PART B: REGIONAL ASPECTS 1567–1612, 1570 (V. R. Barros et al. eds., 2014), https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap28_FINAL.pdf.

[477] Chapin, *supra* note 355, at 521.

[478] F. S. Hu et al., *Tundra Burning in Alaska: Linkages to Climatic Change and Sea Ice Retreat*, Abstract, J. GEOPHYS RES: BIOGEOSCIENCES 115: G04002 (2010), http://onlinelibrary.wiley.com/doi/10.1029/2009JG001270/full.

[479] *See* A. V. Rocha et al., *The Footprint of Alaskan Tundra Fires During the Past Half-Century: Implications for Surface Properties and Radiative Forcing*, ENVIRON RES LETTER 7 (2012), http://iopscience.iop.org/article/10.1088/1748-9326/7/4/044039/meta.

[480] *See* E. E. Jafarov et al., *The Effects of Fire on the Thermal Stability of Permafrost in Lowland and Upland Black Spruce Forests of Interior Alaska in a Changing Climate*, ENVIRON RES LETT 8: 035030, 11 (2011), http://iopscience.iop.org/article/10.1088/1748-9326/8/3/035030/meta; *see also* D. R. N. Brown et al., *Interactive Effects of Wildfire and Climate on Permafrost Degradation in Alaskan Lowland Forests*, 120 J. GEOPHYS RES BIOGEOSCI 1619–37 (2015), http://onlinelibrary.wiley.com/doi/10.1002/2015JG003033/full.

[481] *5 Ways Climate Change is Already Affecting Alaska*, *supra* note 444; *see also Alaska Entering New Era for Wildfires*, CLIMATE CENTRAL (June 24, 2015), http://www.climatecentral.org/news/alaska-entering-new-era-for-

fact, wildfires in the 2000's have "increased nearly tenfold" compared to the 1950s and 60s.[482] There has also been a "dramatic increase" in larger wildfires (those that consume between 10,000 and 50,000 acres).[483] Only three years in the 1950s and 60s saw large wildfires; however, as of June 2015, there had already been over 30 large fires since 2000.[484] In what was described as "the most destructive fire year ever," [485] wildfires burned over 5 million acres in Alaska in 2015 (an area of land about the size of Massachusetts), [486] making the season among the worst in Alaska's recorded history, second only to the record-breaking 2004 wildfire season.[487] Wildfires in 2004 and 2005 burned a larger area than in the 15 years between 1950 and 1964.[488] In 2004, the Taylor Complex Fire burned more than 1,300,000 acres, making it the biggest fire in the record-breaking season, "which ended up seeing roughly 6.5 million acres of forest burned – the highest in U.S. history.[489] In 2007, a single wildfire burned 256,000 acres of Alaska's Arctic slope, making it the largest fire on record for the tundra biome.[490] The blaze lasted over three months and released as much carbon to the atmosphere as had been absorbed by the entire circumpolar Arctic tundra during the previous quarter-century.[491] Alaska's wildfire season is approximately 40 percent longer now than it was in the 1950s; running from May to early August, or 35 days longer than it did sixty years ago.[492] The financial toll taken by wildfires increased in lockstep with their accelerating incidence. For example, in 1995 the U.S. Forest Service dedicated 16% of its budget to wildfires, by 2015 more than half of its budget went to addressing wildfires.[493]

This dramatic uptick in the size and frequency of Alaska wildfires is due to the impacts of climate change, such as hotter, drier, and longer warm-weather seasons, reduced soil moisture,

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wildfires-19146; *see also Baseline and Projected Future Carbon Storage and Greenhouse Gas Fluxes in Ecosystems in Alaska*, *supra* note 379, at 17; *see also* Rosen, *supra* note 355; *see also* U.S. Environmental Protection Agency, *Climate Impacts in Alaska*, *supra* note 354; *see also* J. C. Koch et al., *Runoff Sources and Flow Paths in a Partially Burned, Upland Boreal Catchment Underlain by Permafrost*, 50 WATER RESOURCES RES 8141–58 (2014), http://onlinelibrary.wiley.com/doi/10.1002/2014WR015586/full.

[482] *Alaska Entering New Era for Wildfires*, *supra* note 481; *see also* Rosen, *supra* note 355.

[483] *Alaska Entering New Era for Wildfires*, *supra* note 481.

[484] *Id.*

[485] Alastair Bland, *Catching Fire: Wildfire Season Heats up in the American West*, NEWS REVIEW (July 14, 2016), https://www.newsreview.com/reno/catching-fire/content?oid=21468884; *see also* Chris Mooney, *Alaska's Terrifying Wildfire Season and What It Says About Climate Change*, WASHINGTON POST (July 26, 2015), https://www.washingtonpost.com/news/energy-environment/wp/2015/07/26/alaskas-terrifying-wildfire-season-and-what-it-says-about-climate-change.

[486] Asaf Shalev, *2015 Alaska Wildfire Season Now 2nd Biggest on Record*, ALASKA DISPATCH NEWS (Aug. 10, 2015), http://www.adn.com/article/20150810/2015-alaska-wildfire-season-now-2nd-biggest-record; *Alaska: Climate Change Ground Zero*, *supra* note 354.

[487] Partain, *supra* note 216, at S14.

[488] *Alaska Entering New Era for Wildfires*, *supra* note 481.

[489] Bryan Nelson, *10 of the Worst Wildfires in U.S. History*, MOTHER NATURE NETWORK (June 17, 2013), http://www.mnn.com/earth-matters/wilderness-resources/stories/10-of-the-worst-wildfires-in-us-history.

[490] Michelle C. Mack, *Carbon Loss From an Unprecedented Arctic Tundra Wildfire*, NATURE 475, 489–92 (July 28, 2011), available for download at https://www.researchgate net/publication/51527712_Carbon_loss_from_an_unprecedented_Arctic_tundra_wildfire.

[491] *Id.*; *see also Alaska: Climate Change Ground Zero*, *supra* note 354; *see also* Chapin, *supra* note 355, at 520.

[492] *Alaska Entering New Era for Wildfires*, *supra* note 481

[493] *Alaska: Climate Change Ground Zero*, *supra* note 354.

changes in precipitation, and increased evaporation. [494] Higher temperatures lead to more "standing dead, highly flammable trees that are especially vulnerable to wildfire,"[495] which heightens the risk of more larger and intense fires. Indeed, rising temperatures have been "concurrent with the rise in the number and size of Alaskan wildfires."[496] Years with the most fires and area burned also tend to be the years with the hottest summers and fire seasons.[497] The American Meteorological Society estimates that anthropogenic climate change has increased the risk of fire seasons in Alaska of the severity typified by 2015 by 34%-60%.[498] "Alaska's wildfire season is about 40 percent longer now than it was in the 1950s. The first wildfires start earlier in the year, and the last wildfires are burning longer into the fall. Overall, the wildfire season has increased more than 35 days and is now more than three months long, running from May through early August."[499]

This increase in wildfires has dire consequences on human health, wildlife habitats, and furthers global warming.[500] Wildfire smoke, which is a combination of gases and aerosols[501] negatively affects human health by worsening air quality, and in the process harming eyes, irritating respiratory systems, and worsening chronic heart and lung diseases.[502] The "fine particles present in the [wildfire] smoke . . . can enter into the lungs through the eyes, mouth, and nose, or aggravate preexisting health conditions like lung or heart disease."[503] Wildfires also create yet another feedback loop: they are "not only worsening due to climate change; they also *cause* climate change to worsen."[504] In addition to releasing carbon from burned trees, wildfires also release carbon from burned permafrost.[505] This in turn creates a feedback loop, where "[t]he more severe the fire, the more deeply the Earth is scorched, and the more warming we can expect."[506]

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[494] Natural Resources Defense Council, *Where There's Fire, There's Smoke: Wildfire Smoke Affects Communities Distant from Deadly Flames*, 2 (October 2013), IB:13-09-b, https://www nrdc.org/sites/default/files/wildfire-smoke-IB.pdf; *see also Alaska: Climate Change Ground Zero*, *supra* note 354; *see also* Chapin, *supra* note 355, at 520.
[495] U.S. Environmental Protection Agency, *supra* note 354.
[496] *Alaska Entering New Era for Wildfires*, *supra* note 381.
[497] *Id.*
[498] Partain, J. L., *supra* note 216.
[499] *Alaska Entering New Era for Wildfires*, *supra* note 381.
[500] Chapin, *supra* note 355, at 521; *see also*, NASA Earth Expeditions, *Living Off the Land in a Changing Arctic Climate* (July 15, 2016), https://blogs.nasa.gov/earthexpeditions/2016/07/15/living-off-the-land-in-a-changing-arctic-climate.
[501] NASA Earth Observatory, *Smoke Goes Around the World: Image of the Day* (July 2015), http://earthobservatory.nasa.gov/IOTD/view.php?id=86241.
[502] Centers for Disease Control and Prevention, *Protect Yourself from Wildfire Smoke* (last updated August 7, 2017), http://www.cdc.gov/features/wildfires; *see also* Alaska Department of Health and Human Services, *Fire and Smoke Health Concerns: Frequently Asked Questions* (July 1, 2015), http://dhss.alaska.gov/dph/Epi/eph/Documents/wildfire/FAQ_FireSmoke.pdf; *see also* AirNow, *How Smoke from Fires Can Affect Your Health*, U.S. EPA OFFICE OF AIR AND RADIATION (Jan. 2017), https://airnow.gov/index.cfm?action=smoke.index.
[503] Mooney, *supra* note 485.
[504] *Alaska: Climate Change Ground Zero*, *supra* note 354.
[505] *Id.*; *see also* Mooney, *supra* note 485; *see also* Adam Markham, *6 Ways Climate Change in Alaska Will Affect You*, UNION OF CONCERNED SCIENTISTS (Aug. 31, 2015), http://blog.ucsusa.org/adam-markham/climate-change-in-alaska-864.
[506] *Alaska: Climate Change Ground Zero*, *supra* note 354; *see also* Chapin, *supra* note 355, at 521.

Due to "higher surface air temperatures linked to climate change,"[507] Alaska wildfires are projected to increase 150 to 390 percent by the mid-century.[508] In fact, if warming continues, large fires "will no longer be so extraordinary."[509] Such a phenomenon would bring grave consequences for forests and wildlife habitats. An increase of fires of this magnitude will lead to a "transformation of what has been spruce-dominated forest,"[510] which will change the suitability of these forests for timber production and wildlife, most notably the caribou.[511] Caribou rely on lichens, which grow at the bases of black spruce trees, to survive in the winter. [512] Because lichens "require 50 to 100 years to recover after wildfire," the projected increase of wildfires could lead to a decrease in caribou population, which in turn could be "nutritionally and culturally significant for Alaska Native Peoples."[513] Additionally, some invasive species, which would increase with wildfires, are toxic to moose, another nutritional and cultural significant animal to Alaska Native Peoples.[514] Continued rising temperatures and wildfires will lead to increased impacts on human health, ecology, wildlife, and further global warming.

(b) Ocean Acidification

Ocean acidification, a "direct result of increasing levels of carbon dioxide in the atmosphere,"[515] has been called climate change's "disastrous twin."[516] Alaska is particularly prone to ocean acidification due to the low temperatures and low salt content, caused by "freshwater input from melting sea ice."[517] Acidity in the ocean alters the lives of key plankton and shelled animals,[518] which in turn "alters the food available to important fish species."[519] The

[507] *Alaska: Climate Change Ground Zero*, *supra* note 354.
[508] X. Yue et al., *Impact of 2050 Climate Change on North American Wildfire*, 15 ATMOSPHERIC CHEMISTRY AND PHYSICS 10033–55, 10048 (May 13, 2015), https://www.atmos-chem-phys.net/15/10033/2015/acp-15-10033-2015.pdf; *see also Alaska: Climate Change Ground Zero*, *supra* note 354; *see also Alaska Entering New Era for Wildfires*, *supra* note 381 ("the amount of area burned in Alaskan wildfires is projected to double by 2015 and triple by 2100."); *see also* Balshi, M. S., et al., *Assessing the Response of Area Burned to Changing Climate in Western Boreal North America Using a Multivariate Adaptive Regression Splines (MARS) Approach*, 15 GLOBAL CHANGE BIOLOGY, 578–600, 585 (2009), available for download at https://www.researchgate net/publication/229948796_Assessing_the_response_of_area_burned_to_changing_climate_in_western_boreal_North_America_using_a_Multivariate_Adaptive_Regression_Splines_MARS_approach.
[509] Yereth Rosen, *Warming, Fires, Warming, Fires: How Tundra Wildfires Could Create an Unstoppable Cycle*, ALASKA DISPATCH NEWS, (May 30, 2016), http://www.adn.com/alaska-news/science/2016/05/30/warming-fires-warming-fires-how-tundra-wildfires-could-create-an-unstoppable-cycle.
[510] Rosen, *supra* note 355.
[511] Chapin, *supra* note 355, at 521.
[512] Mooney, *supra* note 485.
[513] Chapin, *supra* note 355, at 521.
[514] *Id.*
[515] Markham, *supra* note 505.
[516] Zoe Schlanger, *So Long, Seafood! Ocean Acidification Projected to Slam Alaskan Fisheries*, NEWSWEEK (July 29, 2014), http://www newsweek.com/ocean-acidification-alaskan-fisheries-alaska-crab-crabs-climate-change-alaska-261756; s*ee also* Markham, *supra* note 505.
[517] Chapin, *supra* note 355, at 521; *see also* Alaska Ocean Acidification Network, *What is Ocean Acidification*, ALASKA OCEAN OBSERVING SYSTEM, http://www.aoos.org/alaska-ocean-acidification-network/about-oa/what-is-ocean-acidification; *see also* Rosen, *supra* note 355.
[518] *See* Laine Welch, *Ocean Acidification Could Erode Bering Strait Crab Stocks Within the Next 20 Years*, ALASKA DISPATCH NEWS, (June 21, 2016), http://www.adn.com/economy/article/ocean-acidification/2016/04/16.
[519] Chapin, *supra* note 355, at 522.

sea creatures in the polar ocean rely on particular conditions in order to survive; "[w]hen those conditions change, so do their populations."[520] Most notably, shelled pteropods – one of the foundational species of the marine food chain in Alaska, and a major source of food for salmon and herring– are particularly susceptible to ocean acidification.[521] According to the Third National Climate Assessment, a "10% decrease in the population of pteropods could mean a 20% decrease in an adult pink salmon's body weight."[522] Data from the California Current Ecosystem indicates that "the incidence of severe pteropod shell dissolution owing to anthropogenic [ocean acidification] has nearly doubled in near shore habitats since pre-industrial conditions…and is on track to triple by 2050."[523] This is just one instance of how ocean acidification can detrimentally affect commercial and subsistence fisheries.[524] Alaska crab are also "among the species expected to be negatively impacted by ocean acidification"[525] as are oysters raised in Alaska. Oyster farmers in state rely on importation of attached oyster larvae from Puget Sound farmers, but those farmers, are "now directly affected by the recent upwelling of acidic waters along the Washington and Oregon coastline," and thus cannot be relied upon.[526] In fact, Oyster seed production in the Northwest has fallen in recent years by as much as eighty percent as oceans become more acidic due to combustion of fossil fuels.[527]

According to a 2015 study done by NOAA, the University of Alaska, and the Woods Hole Oceanographic Research Institute, the "largest and most rapid changes in pH will occur in the Arctic Ocean and the Bering Sea" in the next decade.[528] Ocean acidification will thus "overwhelm the ability of marine calcifiers to build and maintain their shells," which will further impair Alaska's fisheries.[529] Alaskan waters' capacity to further absorb carbon dioxide could be

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[520] Schlanger, *supra* note 516.
[521] Chapin, *supra* note 355, at 522; Alaska Ocean Acidification Network, *What is Ocean Acidification*, Alaska OCEAN OBSERVING SYSTEM, http://www.aoos.org/alaska-ocean-acidification-network/about-oa/what-is-ocean-acidification; *see also* Alaska Department of Fish and Game, *Climate Change Strategy*, 3 (Nov. 2010), https://www.adfg.alaska.gov/static/lands/ecosystems/pdfs/climatechangestrategy.pdf; Schlanger, *supra* note 516.
[522] Chapin, *supra* note 355, at 522.
[523] N. Bednarsek et al., *Limacina Helicina Shell Dissolution as an Indicator of Declining Habitat Suitability Owing to Ocean Acidification in the California Current Ecosystem*. PROC ROY SOC B: BIOLOG SCI 281: 20140123 (2014), http://rspb.royalsocietypublishing.org/content/281/1785/20140123.
[524] Chapin, *supra* note 355, at 522.; *see also Climate Change Strategy*, *supra* note 521; *see also* Alaska Marine Conservation Council, *Ocean Acidification in Alaska*, http://www.akmarine.org/fisheries-conservation/ocean-acidification/ocean-acidification-in-alaska/.
[525] Alaska Ocean Acidification Network, *What is Ocean Acidification*, ALASKA OCEAN OBSERVING SYSTEM, http://www.aoos.org/alaska-ocean-acidification-network/about-oa/what-is-ocean-acidification; *see also* Terry Johnson, *Fisheries Adaptation to Climate Change*, SEA GRANT ALASKA, NOAA, http://seagrant.noaa.gov/Portals/0/Documents/what_we_do/climate/AK%20SG%20Fisheries%20Adaptations%20to%20Climate%20Change.pdf.; Robert f. Joy, et. al., *Ocean Acidification: Monitoring and Measuring the Physiologicaland Population Response of Living Marine Resources in Alaska*, NOAA https://www.afsc.noaa.gov/Quarterly/jas2012/JAS12-Feature2.pdf.
[526] Chapin, *supra* note 355, at 522.
[527] Katie Campbell, Earthfix, *Acidifying Water Takes Toll on Northwest Shellfish*, NOAA PMEL CARBON PROGRAM, https://www.pmel.noaa.gov/co2/story/Acidifying+Water+Takes+Toll+On+Northwest+Shellfish.
[528] Jeremy T. Mathis, Jessica N. Cross, Wiley Evans & Scott C. Doney, *Ocean Acidification in the Surface Waters of the Pacific-Arctic Boundary Regions*, 28 OCEANOGRAPHY 122–35, 126 (June 2015), http://tos.org/oceanography/assets/docs/28-2_mathis2.pdf.
[529] Markham, *supra* note 505.

met anywhere between the year 2025 and 2044.[530] The impacts of ocean acidification on Alaska's marine life will only become more grim after that.[531] These implications are dire not only for Alaska's marine life, but also for the Alaskans that rely upon them as "[t]he seafood industry in Alaska has an estimated value of $5.8 billion and constitutes the largest private sector employer in the state.[532]

(c) Wildlife

Climate change brings major impacts to wildlife in various ecosystems of Alaska.[533] One comprehensive study looking at 60 environmental indicators found that climate change impacts "will be the major drivers of ecological change through 2100."[534] In fact, "[f]orest, tundra, marine, and freshwater ecosystems are all vulnerable to a changing climate, which can influence Alaska's biodiversity in a myriad of complex and unpredictable ways."[535] Alaska is home to five ecological regions with different climate characteristics , as well as "36 fish species, 36 land mammals, nine marine mammals, and more than 160 migratory and resident bird species," which are all connected to and impacted by climate change in different ways. [536] Because Arctic animals "are so specialized to the extreme conditions in which they live, species diversity is low and the food web is relatively small. The depletion of even one species when those conditions change could have a ripple effect on the entire food web."[537] The influx of rising temperatures, declining sea ice, thawing permafrost, increased wildfires, and increased ocean acidification has left Arctic species very sensitive and increasingly vulnerable.[538]

Already, rising temperatures and drier weather have resulted in water scarcity impacting animals across the state of Alaska.[539] Increased storm surges have eroded coastal habitats and loss of sea ice has impacted ice-dependent animals' food sources and habitats.[540] Loss of sea ice "creates a pathway for invasive species and habitat loss for a variety of ice-dependent species,

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[530] *Id.* ("The threshold could be reached by 2025 in the Beaufort Sea, 2027 in the Chukchi Sea and 2044 for the Bering Sea.").
[531] *See* Schlanger, *supra* note 516.
[532] Alaska Ocean Acidification Network, *What is Ocean Acidification*, *supra* note 517.
[533] U.S. Environmental Protection Agency, Climate Impacts in Alaska (January 19, 2017), https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-alaska_.html.
[534] *Alaska: Climate Change Ground Zero*, *supra* note 427; *see also* M. T. Jorgenson et al., *Projected Changes in Diverse Ecosystems from Climate Warming and Biophysical Drivers in Northwest Alaska*, 130 CLIMACTIC CHANGES 131–144, 141 (Jan, 18, 2015), https://link.springer.com/article/10.1007/s10584-014-1302-1.
[535] U.S. Fish and Wildlife Service, *Alaska Climate Change Science* (last updated September 24, 2014), https://www.fws.gov/alaska/climate.
[536] *Climate Change: Alaska's National Wildlife Refuges, Arctic National Wildlife Refuge*, U.S. FISH & WILDLIFE SERV. (last visited May 3, 2017), https://www fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf.
[537] DEFENDERS OF WILDLIFE, *Climate Change and the Arctic National Wildlife Refuge: Which Species are Most at Risk?*, 3, https://www.defenders.org/publications/climate_change_and_the_arctic_national_wildlife_refuge_which_species_are_most_at_risk.pdf.
[538] *Alaska: Climate Change Ground Zero*, *supra* note 354.
[539] *Id.*; *see also Climate Change: Alaska's National Wildlife Refuges, Arctic National Wildlife Refuge*, *supra* note 536.
[540] *Alaska: Climate Change Ground Zero*, *supra* note 354; *see also Climate Change: Alaska's National Wildlife Refuges, Arctic National Wildlife Refuge*, *supra* note 536.

including walruses and polar bears."[541] For instance, the loss of sea ice forces polar bears to swim great distances they would otherwise walk, leading to increased drowning of polar bear cubs.[542] The thaw of permafrost has altered vegetation, a food source for many animals, and contributed to the draining, evaporation, and other alteration of lakes that provide breeding habitat for a variety of birds.[543] Additionally, increased wildfires have impacted forest composition and distribution, further affecting animal food sources and habitats.[544] In fact, in the Pribilof Islands alone, a group of four volcanic islands off the coast of mainland Alaska, global warming is thought to have caused "the decline of 20 [native] species."[545]

The decrease in sea ice caused by climate change means that marine mammals, such as narwhal, and other species are at greater risk of attack by killer whales and that, as such, "killer whales have the potential to reshape Arctic marine mammal distributions and behavior.[546] A study of Arctic and subarctic marine mammal species from 2008 concluded that the hooded seal, the narwhal, and the polar bear are "most sensitive" to the threat of climate change, primarily due to reliance on sea ice and specialized feeding.[547] However, a large variety of Alaska's marine mammals are at risk and impacted from climate change, including narwhal, beluga whales, bowhead whales, fin whales, humpback whales, minke whales, gray whales, killer whales, walruses, ringed seals, bearded seals, harp seals, hooded seals, ribbon seals, spotted seals, and polar bears.[548]

Alaska's salmon populations, which provide subsistence for Native communities and provide a substantial portion of the state economy, face devastating impacts from climate change in the absence of meaningful action. In a study based on the impact of rising temperatures alone,

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[541] U.S. ENVIRONMENTAL PROTECTION AGENCY, CLIMATE IMPACTS IN ALASKA, https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-alaska_.html; *see also* Chapin, *supra* note 355.

[542] *Polar Bear Cubs Drowning Due to Sea Ice Loss, Says Report*, GUARDIAN (July 19, 2011), https://www.theguardian.com/environment/2011/jul/19/polar-bear-cubs-drowning-ice.

[543] *Alaska: Climate Change Ground Zero*, *supra* note 5; *see also* U.S. Environmental Protection Agency, *Climate Impacts in Alaska*, supra note 354; Markham, *supra* note 505; *Climate Change: Alaska's National Wildlife Refuges, Arctic National Wildlife Refuge*, *supra* note 536.

[544] *Alaska: Climate Change Ground Zero*, *supra* note 354; *see* U.S. Environmental Protection Agency, *Climate Impacts in Alaska*, supra note 354; *Climate Change: Alaska's National Wildlife Refuges, Arctic National Wildlife Refuge*, *supra* note 536.

[545] Margot Roosevelt, *Vanishing Alaska: Global Warming is Flooding Villages Along the Coast. Should They Surrender and Move?*, TIME (Sept. 27, 2004), http://content.time.com/time/magazine/article/0,9171,995264,00.html.

[546] G. A. Breed et al., *Sustained Disruption of Narwhal Habitat Use and Behavior in the Presence of Arctic Killer Whales*, Abstract, 114 *PNAS* 2628–33 (2017), https://www ncbi.nlm.nih.gov/pubmed/28223481.

[547] K. L. Laidre et al., *Quantifying the Sensitivity of Arctic Marine Mammals to Climate-Induced Habitat Change*, Abstract, ECOL. APPL. 18 (2 Suppl): S97–125 (2008), https://s3.amazonaws.com/academia.edu.documents/45278297/Quantifying_the_sensitivity_of_Arctic_ma20160502-26464-a8u48y.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1503697380&Signature=tOFkXf9YdjDj46uscXJxED%2FHsOU%3D&response-content-disposition=inline%3B%20filename%3DQuantifying_the_Sensitivity_of_Arctic_Ma.pdf.

[548] S. E. Moore and H. P. Huntington, *Arctic Marine Mammals and Climate Change: Impact and Resilience*, ECOL. APPL. 18 (2 Suppl): 157–65 (2008), http://www.westcoast fisheries.noaa.gov/publications/protected_species/marine_mammals/cetaceans/gray_whales/studies_under_review/moore_and_huntington_2008.pdf.

without considering additional impacts from ocean acidification or other sources, scientists predict project that summer habitats in the North Pacific and part of the Arctic Ocean will decrease 86% for Chinook, 45% for sockeye, 36% for steelhead, and 30% for coho, pink and chum salmon.[549] The open ocean Gulf of Alaska habitat for Chinook and sockeye "could be completely lost by 2100."[550] These represent just some of the profound impacts facing Alaska's salmon due to anthropogenic climate change.[551] Increased landslides, seawater rise, changes in running time and changing zooplankton availability, each associated with climate change, present additional dangers to Alaska's salmon.[552] Further, in addition to warming of freshwater and marine habitat, "altered hydrology in spawning rivers, reduced productivity in nursing habitats, and changed distribution of predator and prey species," and other impacts resulting from anthropogenic climate change are affecting Alaska's salmon.[553] The rapid climate change facing Alaska is also contributing to the spread of *Elodea*, Alaska's first aquatic invasive plant, which threatens salmon spawning and rearing sites, with corresponding impacts on subsistence

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[549] O. I. Abdul-Aziz et al., *Potential Climate Change Impacts on Thermal Habitats of Pacific Salmon (*Oncorhynchus *spp.) in the North Pacific Ocean and Adjacent Seas*, Abstract, 68 CAN. J. FISH AQUAT. SCI. 1660–80, https://ewrel fiu.edu/wp-content/uploads/2011/10/Abdul-Aziz-et-al-CJFAS-2011.pdf; *see also* S. Mauger, *Stream Temperature Monitoring Network for Cook Inlet Salmon Streams 2008-2012, Synthesis Report*, COOK INLETKEEPER FOR ALASKA DEPT ENV CONSERVATION (ACWA 13-01) AND US FISH AND WILDLIFE SERVICE (F12AC01078), https://dec.alaska.gov/water/wqsar/pdfs/Reports/Stream-Temperature-Monitoring-Network-Synthesis-2013-ADEC.pdf (detailing temperature increases in streams around Cook Inlet).

[550] Abdul-Aziz, *supra* note 549.

[551] *See also* J. R. Griffiths and D. E. Schindler *Consequences of Changing Climate and Geomorphology for Bioenergetics of Juvenile Sockeye Salmon in a Shallow Alaska Lake*, 21 ECOL. FRESHWATER FISH 349–62 (discussing effect of warming waters on juvenile sockeye salmon); J. R. Griffiths et al., *Effects of Simultaneous Climate Change and Geomorphic Evolution of Thermal Characteristics of a Shallow Alaskan Lake*, 56 LIMNOL. OCEANOGR. 191–205 (impacts of temperature change on salmon), http://onlinelibrary.wiley.com/doi/10.4319/lo.2011.56.1.0193/epdf; Y. Ishida et al., *Interannual Variability in Stock Abundance and Body Size of Pacific Salmon in the Central Bering Sea*, 55 PROG. OCEANOG. 223–34 (impacts of temperature change on size, distribution, and diet of salmon); S. Mauger et al., *Summer Temperature Regimes in Southcentral Alaska Streams: Watershed Drivers of Variation and Potential Implications for Pacific Salmon*, CAN. J. FISH AQUAT. SCI., http://www.nrcresearchpress.com/doi/pdf/10.1139/cjfas-2016-0076, (temperature impacts due to warming already exceeding incubation and spawning parameters); M. Healey, *The Cumulative Impacts of Climate Change on Fraser River Sockeye Salmon (*Onchorhynchus nerka*) and Implications for Management*, 68 CAN. J. FISH AQUAT. SCI. 718–37, http://www.fishsciences net/reports/2011/CJFAS_68_718-737.pdf, (Climate change impacts on Sockeye salmon); S. P. Johnson and D. E. Schindler, *Trophic Ecology of Pacific Salmon (*Onchorhynchus *spp.) in the Ocean: A Synthesis of Stable Isotope Research*, 24 ECOL. RES. 855, https://www.researchgate net/profile/Daniel_Schindler3/publication/226979254_Trophic_ecology_of_Pacific_salmon_Oncorhynchus_spp_in_the_ocean_A_synthesis_of_stable_isotope_research/links/00b49528da1396ad6d000000/Trophic-ecology-of-Pacific-salmon-Oncorhynchus-spp-in-the-ocean-A-synthesis-of-stable-isotope-research.pdf, (climate change impacts on salmon and salmon prey abundance); M. Kaeriyama et al., *Change in Feeding Ecology and Trophic Dynamics of Pacific Salmon in the Central Gulf of Alaska in Relation to Climate Events*, 13 FISH OCEANOG. 197–207, https://www.researchgate net/publication/227529770_Change_in_feeding_ecology_and_trophic_dynamics_of_Pacific_salmon_Oncorhynchus_spp_in_the_central_Gulf_of_Alaska_in_relation_to_climate_events; E&E News, *Climate Change Threatens Southeast Alaska's Salmon Habitat* (Dec 9, 2013), http://www.eenews.net/climatewire/stories/1059991457 (temperature and rainfall impact projections on SE Alaska salmon).

[552] *See* M. D. Bryant, *Global Climate Change and Potential Effects on Pacific Salmonids in Freshwater Ecosystems of Southeast Alaska*, CLIMATIC CHANGE, (published online Jan 14, 2009), https://www.srs fs fed.us/pubs/ja/ja_bryant005.pdf.

[553] Healey, *supra* note 551.

practices.[554] Additionally, though climate change is resulting in earlier spawning, studies show that predators have adjusted their migrations so they can continue to feed on salmon eggs.[555] Warming in watersheds with steep mountains and a related transition from snow to rain-fed hydrology means that stream discharge and increased flooding are expected to increase 1 to 3 fold in southeast Alaska, diminishing the chance of egg-to-fry survival.[556] The increased loss of snow associated with climate change also threatens salmon because lack of snow cover over spawning gravel increases in freeze-related egg mortality.[557] Finally, the increased levels of concentrations of CO_2 projected for Alaska's freshwater salmon habitat in the next century century, if effective GHG reductions are not implemented, will result in smaller salmon with reduced sense of smell, further reducing chances of survival and reproduction.[558]

Alaska's other species are feeling the impact of climate change as well. In the Barents sea, "generalist" fish such as Atlantic Cod and haddock, as well as many other species, have been moving farther and farther north, changing "species composition and relative abundances" and altering "the arctic food web structure and ecosystem functioning substantially."[559] Additionally early ice retreat is predicted to have impacts on survival of young pollock.[560]

Climate change in Alaska is resulting in changes in breeding frequency of some species. For example, because of warmer lake temperatures and earlier ice breakup, the three-spine stickleback is having two broods per year instead of one.[561] This fish occupies the same habitat as juvenile sockeye salmon so that the increased population of stickleback may result in sockeye

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[554] M. W. Luizza et al., *Integrating Subsistence Practices and Species Distribution Modeling: Assessing Invasive Elodea's Potential Impact on Native Alaskan Subsistence of Chinook Salmon and Whitefish*, 58 ENV. MGMT. 144, available for download at https://www.researchgate net/publication/299379477_Integrating_subsistence_practice_and_species_distribution_modeling_assessing_invasive_elodea's_potential_impact_on_Native_Alaskan_subsistence_of_Chinook_salmon_and_whitefish.

[555] C. J. Sergeant et al., *Predator-Prey Migration Phenologies Remain Synchronized in a Warming Catchment*, 60 FRESHWATER BIOLOGY 724–32 (2014).

[556] C. S. Shanley and D. M. Albert, *Climate Change Sensitivity Index for Pacific Salmon Habitat in Southeast Alaska*, *PLoS One* 9 (8), http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0104799.

[557] *See* W. A. Church and R. L. Burgner, *Studies on the Effect of Winter Climate on Survival of Sockeye Salmon Embryos in the Wood River Lakes, Alaska 1952–1959*, UNIVERSITY OF WASHINGTON, SCHOOL OF AQUATIC AND FISHERIES SCIENCES, https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/15541/0901.pdf?sequence=1&isAllowed=y.

[558] *See* M. Ou et al., *Responses of Pink Salmon to CO2-Induced Aquatic Acidification*, NATURE: CLIMATE CHANGE, https://www.researchgate net/publication/280978965_Responses_of_pink_salmon_to_CO2-induced_aquatic_acidification.

[559] S. Kortsch et al., *Climate Change Alters the Structure of Arctic Marine Food Webs Due to Poleward Shifts of Boreal Generalists*, Abstract, PROC. R. SOC. B 282: 20151546, http://rspb.royalsocietypublishing.org/content/282/1814/20151546.

[560] George L. Hunt, Jr. et al., *Climate Impacts on Eastern Bering Sea Foodwebs: A Synthesis of New Data and an Assessment of the Oscillating Control Hypothesis*, 68 ICES J MAR SCI 1230–43 (2011), https://academic.oup.com/icesjms/article/68/6/1230/703602/Climate-impacts-on-eastern-Bering-Sea-foodwebs-a.

[561] R. A. Hovel et al., *Climate Change Alters the Reproductive Phenology and Investment of a Lacustrine Fish, the Three-Spine Stickleback*, GLOBAL CHANGE BIOLOGY (2016), http://onlinelibrary.wiley.com/doi/10.1111/gcb.13531/abstract.

being outcompeted for resources.[562] As has been seen with beetles and loss of forest resources, changes in breeding frequency of a single organism can have devastating impacts on species in the same habitat.[563]

According to a study conducted by the Defenders of Wildlife, "[s]ixteen of the Arctic National Wildlife Refuge's 38 mammals may be headings for serious trouble."[564] Six species were found to be "extremely vulnerable" to climate change impacts: the polar bear, the arctic fox, the muskox, the tundra vole, the brown lemming, and the collared lemming.[565] "Extremely vulnerable" means that "their numbers or range within the refuge will substantially decrease or disappear by 2050."[566] Ten other species were assessed as "highly vulnerable" and projected to decrease significantly by 2050; these include the lynx, wolverine, caribou, Dall sheep, Alaska marmot, arctic ground squirrel, singing vole, northern bog lemming, tundra shrew, and barren ground shrew.[567]

Impacts to caribou have been particularly pronounced. "Thirty-four of the 43 major herds that scientists have studied worldwide in the last decade are in decline, with caribou numbers plunging 57 percent from their historical peaks."[568] The consensus is that "the causes of global caribou decline are straightforward: rapidly rising Arctic temperatures are throwing caribou out of sync with the environment in which they evolved [and] oil and gas development [and] logging…in the Far North are impinging on the caribou's range…."[569] "Under the persistent increase in greenhouse gas concentrations, reduced connectivity" of habitat due to loss of sea ice "may isolate island-dwelling caribou with significant consequences for population viability."[570] Further, climate change threatens caribou because increasing wildfires reduce the availability of slow-to-recover lichens, a major food source.[571] In the winter habitat range of the one of the largest caribou herds in the world, the Western Arctic herd, scientists forecast up to a 53% increase in area burned by wildfires by 2099, with up to a 61% increase in tundra areas in the

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[562] *Id*.; *see also* Yereth Rosen, *As Water Temperatures Rise, Some Fish Are Breeding Earlier – and More Often*, ALASKA DISPATCH NEWS (Jan. 29, 2017), https://www.adn.com/alaska-news/science/2017/01/29/as-water-temperatures-warm-some-fish-are-breeding-earlier-and-more-often.
[563] *See* Section VI.B.4.a.
[564] *Climate Change and the Arctic National Wildlife Refuge: Which Species are Most at Risk?*, *supra* note 537.
[565] *Id*.
[566] *Id*.
[567] *Id*.
[568] Ed Struzik, *A Troubling Decline in the Caribou Herds of the Arctic*, YALE ENVIRONMENT 360, YALE SCHOOL OF FORESTRY AND ENVIRONMENTAL STUDIES (Sept. 23, 2010) http://e360.yale.edu/features/a_troubling_decline_in_the_caribou_herds_of_the_arctic.
[569] *Id*.
[570] D. A. Jenkins et al., *Loss of Connectivity Among Island-Dwelling Peary Caribou Following Sea Ice Decline*, Abstract, BIOLOGY LETT. 12: 20160235 (2016), https://www.researchgate net/publication/308398209_Loss_of_connectivity_among_island_dwelling_Peary_caribou_following_sea_ice_decline.
[571] K. Joly, *Simulating the Effects of Climate Change On Fire Regimes In Arctic Biomes: Implications For Caribou And Moose Habitat*, 3 ECOSPHERE 1–18, https://pdfs.semanticscholar.org/4f68/ec14604ba7d8b3d02ba6ed1e6e8294c24fac.pdf?_ga=2.90030558.414283468.1503695710-1085550754.1503695710; K. Joly et al., *Fire in the Range of the Western Arctic Caribou Herd*, 8 ALASKA PARK SCIENCE 68–73, https://www nps.gov/articles/aps-v8-i2-c12 htm.

region by 2053 alone, with corresponding impacts on caribou abundance and the subsistence hunters reliant upon them.[572]

Additionally, climate change poses extreme risks to Alaska moose; rising temperatures are causing the species to move farther north and exposure to the higher number of winter ticks associated with warming can weaken moose's immune systems leading to illness and often death, especially in calves.[573] Decreased snowpack and earlier snowmelt associated with climate change leaves snowshoe hares without camouflage, exposing a "critical player[] in forest ecosystems" to greater risk of predation.[574] Alaska's rapidly changing climate was such that snowshoe hares were not even established in northern Alaska until 1977 or 1978 until warming and associated expanded shrub habitat facilitated their introduction – yet another example of changing species ranges effectuated by climate change.[575]

Anthropogenic climate change also poses imminent threats to Alaska's numerous bird species. Changes in tundra vegetation are predicted to drastically alter the extent and range of songbird breeding habitat.[576] Likewise, climate change endangers arctic sea birds dependent on sea ice, such as the ivory gull, leading to their decline.[577] Scientists predict that breeding conditions for Arctic migratory birds could shift, contract, and collapse by 2070 due to climate change."[578] Of 24 shorebird species assessed in one study alone, 66%-83% could lose most of their breeding area and these declines will be fastest in western Alaska.[579] Some arctic bird species are seeing a reduction in body size as a result of a warming climate, with cascading effects impacting these species' abilities to feed, and consequently, their survival.[580] In Alaska's

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[572] *Id.*

[573] U.S. Dept. of Interior, *9 Animals That Are Feeling the Impacts of Climate Change*, https://www.doi.gov/blog/9-animals-are-feeling-impacts-climate-change.

[574] *Id.*

[575] K. D. Tape et al., *Novel Wildlife in the Arctic: The Influence of Changing Riparian Ecosystems and Shrub Habitat Expansion on Snowshoe Hares*, Abstract, 22 GLOBAL CHANGE BIOLOGY 208–19, http://onlinelibrary.wiley.com/doi/10.1111/gcb.13058/abstract; *see also* T. Vowles et al., *Contrasting Impacts of Reindeer Grazing in Two Tundra Grasslands*, 12 ENVIRON. RES. LETTERS (2017), http://iopscience.iop.org/article/10.1088/1748-9326/aa62af, (Detailing changes in vegetation and impact on reindeer due to climate change).

[576] *See* N. T. Boelman et al., *Greater Shrub Dominance Alters Breeding Habitat and Food Resources for Migratory Songbirds in Alaskan Arctic Tundra*, Abstract, 21 GLOBAL CHANGE BIOLOGY 1508–20 (2014, https://www.ncbi.nlm.nih.gov/pubmed/25294359).

[577] O. Gilg et al., *Living on the Edge of a Shrinking Habitat: The Ivory Gull, Pagophila Eburnea, an Endangered Sea-Ice Specialist*, 12 BIOLOGY LETT. (2016), https://www.researchgate net/publication/309618358_Living_on_the_edge_of_a_shrinking_habitat_The_ivory_gull_Pagophila_eburnea_an_endangered_sea-ice_specialist.

[578] Wauchope et al,. *Rapid Climate-Driven Loss of Breeding Habitat for Arctic Migratory Birds*, Abstract, 23 GLOBAL CHANGE BIOLOGY 1085–94 (2016), http://onlinelibrary.wiley.com/doi/10.1111/gcb.13404/full.

[579] *Id.*; *see also* J. Liebezet et al., *Assessing Climate Change Vulnerability of Breeding Birds in Arctic Alaska*, A report prepared for the Arctic Landscape Conservation Cooperative, Wildlife Conservation Society, North America Program, Bozeman, MT. 167 (2012), http://arcticlcc.org/assets/products/ARCT2011-11/reports/Vulnerability_Assessment_report_WCS_2012.pdf.

[580] J. A. van Gils et al., *Body Shrinkage Due to Arctic Warming Reduces Red Knot Fitness in Tropical Wintering Range*, Abstract, 352 SCIENCE 819–21 (2016), https://www.researchgate net/publication/303028008_Body_shrinkage_due_to_Arctic_warming_reduces_red_knot_fitness_in_tropical_wintering_range.

boreal forests, climate change is expected to significantly alter the mix of the numerous bird species which inhabit the ecosystem: central Alaska could gain as many as 80 species and lose as many as 69 species.[581] In 2015 the Audubon Society published "Audubon's Birds and Climate Report: A Primer for Practitioners."[582] In connection with the report, Audubon published a map set showing the extent of habitat loss projected for 50 of Alaska's bird species, showing that some of the state's most iconic bird species are projected to lose all, or nearly all of their suitable habitat to climate change.[583] The hardest impacts will be on the northern hawk owl, bohemian waxwing, American three-toed woodpecker, merlin, Barrow's goldeneye duck, and red-necked grebe, which will lose 90-100% of their summer habitat and over half their winter habitat.[584] The Boreal Owl will lose 100% of winter habitat.[585] Of 50 birds analyzed for Alaska, all but 3 will lose more than half of their summer habitat and half will lose more than half of their winter habitat.[586] This includes common and iconic species such as the bald eagle, loons, and red crossbills.[587]

Alaska's insects, important pollinator and prey species in Alaska's complex foodweb, are also threatened by climate change. Studies indicate that climate change is resulting in smaller body size in Arctic butterflies, which affects dispersal capacity and fecundity such that ongoing rapid climate change is likely to present severe challenges to such species.[588] With increased warming and expansion of shrubs into open tundra, scientists predict changes in arthropod abundance, richness, and diversity with "important ecological effects on arctic food webs since arthropods play important ecological roles in the tundra, including in decomposition and trophic interactions."[589]

Further unabated global warming will only lead to a greater likelihood that Alaska's extremely and highly vulnerable animals will decrease in abundance and range.[590]

(d) Vegetation

Climate change also registers profound ecological effects through changes in vegetation. "Global vegetation models predict that boreal forests will shift first at the biome's margins, with evergreen forest expanding into current tundra while being replaced by grasslands or temperate

[581] G. M. Langham et al., *Conservation Status of North American Birds in the Face of Future Climate Change*, 10 PLOS ONE e0135350 (2015), http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0135350.
[582] Gary Langham, et. al, *Audubon's Birds and Climate Change Report: A Primer for Practitioners*, NATIONAL AUDUBON SOCIETY (2015), http://climate.audubon.org/sites/default/files/NAS_EXTBIRD_V1.3_9.2.15%20lb.pdf.
[583] *See Alaska*, NATIONAL AUDUBON SOCIETY, http://climate.audubon.org/geographical-search/alaska.
[584] *Id*.
[585] *Id*.
[586] *Id*.
[587] *Id*.
[588] J. J. Bowden et al., *High-Arctic Butterflies Become Smaller with Rising Temperatures*, Abstract, 11 BIOLOGY LETT (2015), http://rsbl royalsocietypublishing.org/content/11/10/20150574.
[589] M. E. Rich et al., *Arctic Arthropod Assemblages in Habitats of Differing Shrub Dominance*, Abstract, 36 ECOGRAPHY 994–1003 (2013), http://onlinelibrary.wiley.com/doi/10.1111/j.1600-0587.2012.00078.x/abstract.
[590] *Climate Change and the Arctic National Wildlife Refuge: Which Species are Most at Risk?*, *supra* note 146.

forest at the biome's southern edge."[591] A recent study detailed alarming impacts for a variety of high-latitude evergreens, noting substantial mortality of western hemlock, Sitka spruce, and yellow-cedar linked to the transition from snowy to rainy winters and projecting continued high mortality rates at northern latitudes as warming worsens.[592]Warmer temperatures allow tree species previously found at lower altitudes invade, and alter, higher altitude and tundra ecosystems.[593]

5 *Human Health*

Climate change impacts can also affect human health by: increasing the incidence of accidental injuries; affecting water supply, safety, and quality; affecting food supply, safety, and distribution; increasing the risk and geographical distribution of parasites, allergens, and vector-borne and infectious diseases; and impacting mental health, among other impacts.[594] Although Alaska's population is estimated to be under 800,000 people,[595] Alaska is "on the front lines in dealing with our changing global climate," and of one of the first regions to experience the impacts of climate change.[596] As a result, Alaskans are particularly vulnerable to the human health impacts of climate change. Some villagers have even been called America's first "climate refugees."[597] Continued global warming will only worsen the health impacts to all Alaskans.

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[591] P. S. A. Beck et al., *Changes in Forest Productivity Across Alaska Consistent with Biome Shift,* Abstract. 14 ECOLOGY LETTERS 373–79 (2011), http://onlinelibrary.wiley.com/doi/10.1111/j.1461-0248.2011.01598.x/abstract; *see also R. K.* Danby and D. S. Hik *Variability, Contingency and Rapid Change in Recent Subarctic Alpine Tree Line Dynamics*, 95 J. ECOLOGY 352–63 (2007), https://www.researchgate net/publication/227983418_Variability_contingency_and_rapid_change_in_recent_subarctic_alpine_tree_line_dynamics.

[592] *See* B. Buma et al., *Emerging Climate-Driven Disturbance Processes: Widespread Mortality Associated With Snow-to-Rain Transitions Across 10˚ of Latitude and Half the Range of a Climate-Threatened Conifer*, GLOBAL CHANGE BIOLOGY, https://www.ncbi.nlm.nih.gov/pubmed/27891717.

[593] Andrea Lloyd et. al., *Patterns and Dynamics of Treeline Advance on the Seward Peninsula*, Alaska, 107 JOURNAL OF GEOPHYSICAL RESEARCH ATMOSPHERES 8161 (Jan. 30, 2002), http://onlinelibrary.wiley.com/doi/10.1029/2001JD000852/abstract.

[594] *See generally Alaska Climate Change Strategy's Adaptation Advisory Group Final Report,* at 7-1–7-12 (Jan. 2010), http://climatechange.alaska.gov/aag/aag.htm; A. Crimmins et al., *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, USGCRP (2016), https://health2016.globalchange.gov/downloads;
U.S. EPA, *Climate and Health Resources Alaska* (June 2016), https://www.epa.gov/sites/production/files/2016-11/documents/alaska-fact-sheet.pdf; Michael Brubaker, James Berner, Raj Chavan & John Warren, *Climate Change and Health Effects in Northwest Alaska*, 4 GLOBAL HEALTH ACTION (2011) http://www.tandfonline.com/doi/full/10.3402/gha.v4i0.8445;

[595] UNITED STATES CENSUS BUREAU, *Alaska Quickfacts*, https://www.census.gov/quickfacts/table/PST045215/02.

[596] Deke Arndt, *Alaska: Last Frontier on the Front Lines*, NOAA (May 20, 2016), https://www.climate.gov/news-features/blogs/beyond-data/alaska-last-frontier-front-lines-climate-change.

[597] *See* Rosen, *supra* note 355; *see also* Kate Shepphard, *Climate Change Takes a Village as the Planet Warms, a Remote Alaskan Town Shows Just How Unprepared We Are*, HUFFINGTON POST (Jan. 6, 2015), http://www.huffingtonpost.com/2014/12/14/shishmaref-alaska-climate-change-relocation_n_6296516 html; *see also* Suzanne Goldenberg, *America's First Climate Refugees*, GUARDIAN (May 13, 2013), http://www.theguardian.com/environment/interactive/2013/may/13/newtok-alaska-climate-change-refugees; *see also* Adam Wernick, *Will These Alaska Villagers be America's First Climate Change Refugees?*, PERFORMANCE REVIEW INSTITUTE (August 9, 2015), http://www.pri.org/stories/2015-08-09/will-residents-kivalina-alaska-be-first-climate-change-refugees-us.

Declining sea ice has and will continue to lead, directly and indirectly, to unintentional injuries to Alaskans.[598] As sea ice decreases in volume and thickness,[599] hunting, fishing, and travel become more dangerous.[600] Further, loss of sea ice increases the vulnerability of coastal towns and villages to storm surges and increased precipitation and more extreme weather can further increase the risks of floods and drowning.[601] These injuries are "already a significant cause of mortality among Arctic residents."[602] Global warming has also led to an increase in dangerous landslides and rockfalls.[603]

Additionally, rising temperatures and permafrost thaw will greatly impact the water supply and quality in Alaska.[604] Climate change has already led to changes in Alaska's growing season,[605] and climate change is predicted to result in food scarcity, water scarcity, and an increase of wildfires in Alaska.[606] Others, like those residing on Point Hope, face disruption of safe drinking water from a temperature-driven increase in organic material in an Arctic tundra lake.[607]

Moreover, warming and thawing permafrost releases toxic pollutants like mercury and pesticides into the air and oceans[608] and "impacts water availability and water quality…."[609] The warming climate causes increased accumulation of mercury in waters and bioaccumulation in

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[598] *See* Brubaker, *supra* note 594, at 2; *see also* Tenaya M. Sunbury & David Driscoll, *A Human Health Perspective on Climate Change: Promoting Community-Based Adaptation Planning for Climate Change in Alaska*, 17 INSTITUTE FOR CIRCUMPOLAR HEALTH STUDIES, UNIV. ALASKA ANCHORAGE (Nov. 17, 2011), https://accap.uaf.edu/sites/default/files/2011_11_Sunbury_health.pdf.

[599] *See* Sections VI.A.5, VI.B.3.(a).

[600] *See* Brubaker, *supra* note 594, at 2; *see also* Alan J. Parkinson & James Berner, *Climate change and Impacts on Human Health in the Arctic: An International Workshop on Emerging Threats and the Response of Arctic Communities to Climate Change*, 68:1 INTL J. CIRCUMPOLAR HEALTH 84, 84 (Feb. 2008), http://www.tandfonline.com/doi/pdf/10.3402/ijch.v68i1.18295; *see also* Chapin, *supra* note 355, at 517.

[601] *See* Brubaker, *supra* note 594, at 2; *see also* Chapin, *supra* note 355, at 516; *see also* NOAA, *Arctic Weather and Extreme Events*, U.S. Climate Resilience Toolkit (last modified January 3, 2017), https://toolkit.climate.gov/regions/alaska-and-arctic/arctic-weather-and-extreme-events.

[602] Parkinson, *supra* note 600, at 84.

[603] Temme, A.J.A.M. 2015. *Using Climber's Guidebooks to Assess Rock Fall Patterns Over Large Spatial and Decadal Temporal Scales: An Example From the Swiss Alps*. GEOGRAFISKA ANNALER: SERIES A, PHYS GEOG 97:793-807, http://onlinelibrary.wiley.com/doi/10.1111/geoa.12116/full.

[604] Brubaker, *supra* note 594, at 4; O'Donnell, JA, et al.. 2016. *Dissolved organic matter composition of Arctic rivers: Linking permafrost and parent material to riverine carbon.* Global Biogeochem Cycles 30 (12): 1811–26, https://www.researchgate net/publication/310816564_Dissolved_organic_matter_composition_of_Arctic_rivers_Linking_permafrost_and_parent_material_to_riverine_carbon.

[605] U.S. FOREST SERVICE, *Climate Change: Anticipated Effects on Ecosystem Services and Potential Actions by the Alaska Region*, 6 (2010), http://www fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_038171.pdf.

[606] Chapin, *supra* note 355, at 516; *see also* Ed Struzik, *Food Insecurity: Arctic Heat Is Threatening Indigenous* LIFE, YALE ENVIRONMENT 360, YALE SCHOOL OF FORESTRY AND ENVIRONMENTAL STUDIES (March 17, 2016), http://e360.yale.edu/features/arctic_heat_threatens_indigenous_life_climate_change; *see also* Elizabeth Grossman, *Natural Food, Unnatural Shortages*, Alaska Dispatch News (November 22, 2014), https://www.adn.com/we-alaskans/article/natural-food-unnatural-shortages/2014/11/23; see *also* Section VI.B.4.(a).

[608] Rosen, *supra* note 355

[609] Brubaker, *supra* note 594, at 4; *see also* Schuster, PF, et al.. 2011. *Mercury export from the Yukon River Basin and potential response to a changing climate*. Env Sci Technol 45 (21): 9262-9267, https://pubs.er.usgs.gov/publication/70006305

wildlife, including in fish and other wildlife relied upon for traditional subsistence diets.[610] Increased wildfires from climate change also means that the mercury emitted from these fires will serve only to compound this problem.[611] Climate impacts to Alaska's hydrologic resources can result in "damag[e] and disrupt[ion to] water and sanitation infrastructure,"[612] ultimately leading to infectious diseases, like food- and water-borne diseases.[613] And, according to the CDC, Alaska should expect cholera outbreaks due to warming ocean water.[614] Changes to the quality and quantity of Alaska's water systems will have a multitude of significant direct and indirect impacts on Alaskans' health. Further, "[c]limate change is melting permafrost soils that have been frozen for thousands of years, and as the soils melt they are releasing ancient viruses and bacteria that, having lain dormant, are springing back to life."[615] The dangers of exposure to permafrost-preserved pathogens was realized in 2016 when 2,000 reindeer and at least twenty people contracted anthrax after thawing permafrost exposed an infected reindeer corpse, which had died 75 years earlier.[616] One twelve year old boy lost his life as a result of exposure to the disease. Scientists fear that thawing permafrost could expose people to additional pathogens, "including some that have caused global epidemics in the past."[617]

Alaska's climate change induced warming increases the risk and exposure of animals and humans alike to vector borne diseases including, brucellosis, toxoplasmosis, trichenellosis,

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[610] *See*, Carrie, J, et al.. 2010. *Increasing contaminant burdents in an Arctic fish, burbot (Lota lota) in a warming climate*. Environ Sci Technol 44: 316–22, http://pubs.acs.org/doi/abs/10.1021/es902582y; Chetelat, J and M Amyot. 2009. *Elevated methylmercury in High Arctic Daphnia and the role of productivity in controlling their distribution*. Global Change Biology 15: 706-718, http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2486.2008.01729.x/abstract; Gaden, A, et al., 2009. *Mercury trends in ringed seals (Phoca hispida) from the Western Canadian Arctic since 1973: associations with length of ice-free seasons*. Environ Sci Technol 43: 3646-3988, http://pubs.acs.org/doi/abs/10.1021/es803293z; Hammerschmidt, CR, et al., 2006. *Biogeochemical cycling of methylmercury in lakes and tundra watersheds of Arctic Alaska*, Environ Sci Technol 40: 1204-1211, https://www.researchgate net/publication/7206207_Biogeochemical_Cycling_of_Methylmercury_in_Lakes_and_Tundra_Watersheds_of_Arctic_Alaska; St. Pierre, KA, et al., 2014. *Temperature and the sulfur cycle control monomethylmercury cycling in high Arctic coastal marine sediments from Allen Bay, Nunavut, Canada*, Environ Sci Technol 48: 2680-2687, (2014), download available at https://www.researchgate net/publication/260370410_Temperature_and_the_Sulfur_Cycle_Control_Monomethylmercury_Cycling_in_High_Arctic_Coastal_Marine_Sediments_from_Allen_Bay_Nunavut_Canada.

[611] *See* Wiedinmyer, C and H Friedli. 2007. *Mercury emission estimates from fires: an initial inventory for the United States*. Environ Sci Technol 41: 8092-9098, http://pubs.acs.org/doi/abs/10.1021/es071289o.

[612] Brubaker, *supra* note 594 at 3.

[613] Sunbury, *supra* note 598, at 17.

[614] *See* Brian Owens, *Warming seas linked to rise in cholera bacteria in Europe and US*, NEW SCIENTIST (Aug. 8, 2016) ("We have seen *Vibrio* outbreaks in places that were previously too cold for *Vibrio*, like parts of Alaska," says Karen Wong, from CDC's division of foodborne, waterborne and environmental diseases."), available at https://www.newscientist.com/article/2100371-warming-seas-linked-to-rise-in-cholera-bacteria-in-europe-and-us.

[615] Jasmin Fox-Skelly, *There are Diseases Hidden in Ice, and They Are Waking Up*, BBC (May 4, 2017), https://www.pri.org/stories/2015-06-24/thawing-permafrost-could-have-catastrophic-consequences-scientists-warn.

[616] *Id*.

[617] *Id*.

giardasis/cryptosporidiosis, echinococcosis, rabies, and tulameria.[618] A changing climate also exposes Alaskans to substantial increases in insect stings and airborne allergens.[619]

Finally, extreme weather events like heavy rain, flooding, and drought can have dire health impacts, particularly among villages on the coast.[620] For instance, as already experienced in the village of Newtok, storm surges "can raise tide levels 10 to 15 feet above normal" and cause severe flood events, which can "permeate the village water supply, spread contaminated waters through the community, displace residents from homes, destroy subsistence food storage, and shut down essential utilities."[621]

6. *Impacts on Alaska Native Communities*

Alaska Native communities have been "among the first American populations to feel the effects of global climate change."[622] Most Alaska Native communities have historically lived on water – either along the shores of Alaska's seas or the banks of its rivers – migrating to inland and coastal locations seasonally.[623] In the past 30 years, 100-300 feet of coastline has washed away from the north coast of Alaska between the U.S.-Canadian border and Icy Cape,[624] and according to the U.S. Geological Study, 84 percent of the Alaska coast is eroding.[625] This is shoreline lost to all Alaskans, but it is Alaska Native communities – collectively making up

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[618] *See., e.g.*, Karsten Hueffer et al., *Zoonotic Infections in Alaska: Disease Prevalence, Potential Impact of Climate Change and Recommended Actions for Earlier Disease Detection, Research, Prevention and Control*, 72 INTL J. CIRCUMPOLAR HEALTH (2013), https://www.ncbi nlm nih.gov/pmc/articles/PMC3568173/pdf/IJCH-72-19562.pdf.

[619] Umair Irfan, *Climate Change Expands Allergy Risk*, SCIENTIFIC AMERICAN (April 30, 2012), https://www.scientificamerican.com/article/climate-change-expands-allergy-risk; Eliza Barclay, *Stinging wasps moving north due to global warming?*, NATIONAL GEOGRAPHIC NEWS (July 16, 2008), http://news.nationalgeographic.com/news/2008/07/080716-wasps-stings.html; Jeffrey Demain & Bradford Gessner, *Increasing Incidence of Medical Visits Due to Insect Stings in Alaska*, STATE OF AK EPIDEMIOLOGY BULL. (May 2, 2008), http://epibulletins.dhss.alaska.gov/Document/Display?DocumentId=242.

[620] *Id.*; *see also* Brubaker, *supra* note 594, at 3–4; *see also* Parkinson, *supra* note 163, at 84; *see generally* Jacob Bell, Mike Brubaker, Kathy Graves & Jim Berner, *Climate Change and Mental Health: Uncertainty and Vulnerability for Alaska Natives*, CENTER FOR CLIMATE AND HEALTH (CCH Bulletin No. 3, April 14, 2010), *available at* http://anthc.org/wp-content/uploads/2016/01/CCH-Bulletin-No-3-Mental-Health.pdf.

[621] *See* COMMUNITY OF NEWTOK AND THE NEWTOK PLANNING GROUP, *Relocation Report: Newtok to Mertarvik* 7 (Aug. 2011), https://www.commerce.alaska.gov/web/Portals/4/pub/Mertarvik_Relocation_Report_final.pdf.

[622] Daniel Cordalis & Dean B. Suagee, *The Effects of Climate Change on American Indian and Alaska Native Tribes*, 22 NAT. RESOURCES & ENVIRONMENT 45, 47 (2008), https://www.americanbar.org/content/dam/aba/publications/natural_resources_environment/2008_winter/nre_win08_cordalis_suagee.authcheckdam.pdf.

[623] Robin Bronen, *Climate-Induced Displacement of Alaska Native Communities*, ALASKAN IMMIGRATION JUSTICE PROJECT (Jan, 30, 2013), http://www.brookings.edu/~/media/research/files/papers/2013/1/30-arctic-alaska-bronen/30-climate-alaska-bronen-paper.pdf.

[624] Ann E. Gibbs et al., *National Assessment of Shoreline Change—A GIS Compilation of Vector Shorelines and Associated Shoreline Change Data for the North Coast of Alaska, U.S.-Canadian Border to Icy Cape*: U.S. Geological Survey Open-File Report 2015-1030, http://pubs.usgs.gov/of/2015/1030; *see also* Margot Roosevelt, *Vanishing Alaska: Global Warming is Flooding Villages Along the Coast. Should They Surrender and Move?,* TIME (Sept. 27, 2004), http://content.time.com/time/magazine/article/0,9171,995264,00.html, Associated Press, *Erosion Eating Away at Northern Coast, USGS Says*, FOX NEWS (July 2, 2015), http://www.foxnews.com/us/2015/07/02/erosion-eating-away-at-northern-alaska-coast-usgs-says html.

[625] Associated Press, *supra* note 624.

nearly 15% of Alaska's total population[626] – who are becoming "climate refugees"[627] in their own state.

"Alaska Native, and other indigenous communities across the U.S. share unique historical and cultural relationships with tribal or ancestral lands, significantly shaping their identities and adaptive opportunities."[628] This deep connection with the land is integral to Alaska Natives' culture: Alaskan land and water has sustained these communities for thousands of years – physically and spiritually.[629] However, this unique relationship to the environment and land has left Alaska Native communities extremely vulnerable to climate change impacts.

Climate change impacts observed by Alaska Native communities, including thinning sea and river ice, thawing permafrost, changes in human, plant, and animal health and lives, and rising sea levels, "indicate a widespread awareness that climate is changing in ways that were not anticipated based on traditional knowledge."[630] Changes in sea and river ice have affected the fishing and hunting of traditional animals, which is important both "nutritionally and culturally."[631] "Changing sea ice patterns affect the animals themselves as well as access to them by hunters."[632] Thinning sea and river ice has made fishing and hunting marine animals, like walrus and seals, more dangerous and difficult, while also changing migratory patterns.[633]

Climate change is impacting the health and livelihoods of many Alaska Native communities.[634] "Examples of negative health effects include loss of critical infrastructure such

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[626] *Quickfacts - Alaska*, US CENSUS, https://www.census.gov/quickfacts/table/PST045215/02.
[627] *See*, Yereth Rosen, *Populations on The Rise in Alaskan Villages Threatened by Erosion, Changing Climate*, ALASKA DISPATCH NEWS (July 10, 2016), http://www.adn.com/arctic/2016/07/10/populations-on-the-rise-in-alaska-villages-threatened-by-erosion-changing-climate.
[628] Bennett, T. M. B., et al., *Climate Change Impacts in the United States: The Third National Climate Assessment: Ch. 12: Indigenous Peoples, Lands, and Resources*, U.S. GLOBAL CHANGE RESEARCH PROGRAM, 297–317 (2014), download available at https://www.researchgate net/publication/262835292_Ch_12_Indigenous_Peoples_Lands_and_Resources_Climate_Change_Impacts_in_the_United_States_The_Third_National_Climate_Assessment.
[629] Patricia Cochran et al., *Indigenous Frameworks for Observing and Responding to Climate Change in Alaska*, *in* CLIMATE CHANGE AND INDIGENOUS PEOPLE IN THE UNITED STATES 50 (JULIE KOPPEL MALDANADO ET AL. eds., 2014), https://books.google.com/books?id=Y6kpBAAAQBAJ&pg=PA49&lpg=PA49&dq=Indigenous+Frameworks+for+Observing+and+Responding+to+Climate+Change+in+Alaska&source=bl&ots=R7GY2kfQsx&sig=va5aDj-_gIHqy-O1csBFiVMQKjo&hl=en&sa=X&ved=0ahUKEwiM4vTguPPVAhXHlVQKHaH-DQsQ6AEIPTAE#v=onepage&q=Indigenous%20Frameworks%20for%20Observing%20and%20Responding%20to%20Climate%20Change%20in%20Alaska&f=false.
[630] *Id.* at 51–52.; *see also* Robin Bronen & Denise Pollock, *Rights, Resilience, and Community-Led Relocation: Perspectives from Fifteen Alaska Native Communities*, ALASKA INSTITUTE FOR JUSTICE 2017, http://www.akijp.org/wp-content/uploads/2017/05/AIJ-Final-Adaptation-Workshop-Publication.pdf.
[631] Cochran, *supra* note 629, at 52.
[632] Henry P. Huntington, Lori T. Quakenbush, Mark Nelson, *Effects of Changing Sea Ice on Marine Mammals and Subsistence Hunters in Northern Alaska From Traditional Knowledge Interviews*, 12 BIOLOGY LETT. (Aug. 4, 2016), http://rsbl.royalsocietypublishing.org/content/roybiolett/12/8/20160198 full.pdf.
[633] Cochran, *supra* note 629, at 50.
[634] *See* Michael Brubaker et al., *Climate Change in Kivalina, Alaska: Strategies for Community Health*, ALASKA NATIVE TRIBAL HEALTH CONSORTIUM (Jan. 2011), http://www.cidrap.umn.edu/sites/default/files/public/php/26952/Climate%20Change%20HIA%20Report_Kivalina.p

as water distribution systems from erosion and flooding, food insecurity related to poor harvest, spoiling of food or low confidence in the safety of food, increases in risk of injury related to working and traveling in an uncertain or dangerous environment, and mental stress related to difficult or frightening conditions and uncertainty about the future."[635] Thawing permafrost can increase the risk of skin and respiratory infections, and magnify the risk of failure or lack of adequate drinking water systems, sanitary sewage disposal, and usable landfills.[636] Additionally, severe wildfires, which are increasingly occurring, "increase risk to life and property, alter hunting opportunities" and present risks of "both physical and mental health effects from wildfire smoke."[637] These effects are particularly disruptive for subsistence Native communities.

However, it is "the village relocation issue" that the Alaska Climate Impacts Assessment Commission found to be "perhaps the most striking" of the myriad impacts threatening Alaska.[638] Due to the melting of ice and glaciers, the thawing of permafrost, and the increase of storms and precipitation, Alaska Native villages are suffering from an unprecedented rate of flooding and erosion.[639] This flooding and erosion is literally consuming Native lands—and thus a large swath of Alaska Native culture and heritage—forcing entire communities to abandon their homes and relocate. The impacts of relocation are as dire as they are complex, and "[t]he convergence of immediate threats, substantial human need, and prohibitive costs presents decision-makers at all levels of government with daunting challenges."[640] Climate change has caused and will continue to cause community relocation. Thus, until CO_2 levels are lowered and

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df; ANTHC, *Community Observations on Climate Change: Arctic Village, Fort Yukon and Venetie, Alaska* (Nov. 2016), http://anthc.org/wp-content/uploads/2016/01/Upper-Yukon-River-Climate-Assessment-Final.pdf; Michael Brubaker et al., *Climate Change in the Bering Strait Region* (March 2015) http://anthc.org/wp-content/uploads/2016/01/CCH_AR_032015_Climate-Change-Bering-Strait-Region.pdf; Sue Flensburg, et al., *Community Observations on Climate Change: Nushagak River Trip Report*, (Sept. 2014) http://anthc.org/wp-content/uploads/2016/01/CCH_AR_092014_Climate-Change-and-Upper-Nushagak-River.pdf; *and* other Alaska Native Tribal Health Consortium Assessment Reports, *available at* http://anthc.org/what-we-do/community-environment-and-health/center-for-climate-and-health/climate-health-3; *see also* AFFILIATED TRIBES OF NORTHWEST INDIANS, *Resolution #16-52* (2016) (ATNI "a regional organization comprised of American Indians/Alaska Natives and tribes in the states of . . . Alaska" notes in its resolution asking for federal government action and consultation regarding climate change issues unique to each tribe, that "a growing body of literature illustrates the unique issues facing Tribes regarding climate change."), http://www.atnitribes.org/sites/default/files/Res-16-52.pdf.

[635] Michael Brubaker, et al., *Climate in the Bering Strait Region*, ALASKAN NATIVE TRIBAL HEALTH CONSORTIUM 56 (March 2015), https://anthc.org/wp-content/uploads/2016/01/CCH_AR_032015_Climate-Change-Bering-Strait-Region.pdf.

[636] AFFILIATED TRIBES OF NORTHWEST INDIANS, *Resolution #16-52* (2016), supra note 634; *see also* ALASKA NATIVE TRIBAL HEALTH CONSORTIUM ASSESSMENT REPORTS, http://anthc.org/what-we-do/community-environment-and-health/center-for-climate-and-health/climate-health-3.

[637] Cochran, *supra* note 629.

[638] ALASKA CLIMATE IMPACT ASSESSMENT COMMISSION, *Final Report to the Legislature*, March 17, 2008, https://climatechange.alaska.gov/aag/docs/O97F17502.pdf.

[639] *See* U.S. GOVERNMENT ACCOUNTABILITY OFFICE, *Report to Congressional Committees: Alaska Native Villages: Most Are Affected by Flooding and Erosion, but Few Qualify for Federal Assistance* (Dec. 2003), http://www.gao.gov/new.items/d04142.pdf [hereinafter "GAO 2003"]; *see also* GAO, *Alaska Native Villages: Limited Progress Has Been Made on Relocating Villages Threatened by Flooding and Erosion* (June 3, 2009), http://www.gao.gov/assets/300/290468.pdf [hereinafter "GAO 2009"]; Bronen, *supra* note 630.

[640] *Final Commission Report to the Alaska State Legislature*, ACIAC 3 (Mar. 17, 2008), http://climatechange.alaska.gov/aag/docs/O97F17502.pdf.

a healthy atmosphere and stable climate system are restored, Alaska's decision-makers will continue to be confronted by the daunting challenge and tragic reality climate change-induced Native village displacement.

(a) Living Along Water

Alaska is surrounded by saltwater bodies on three sides - the Beaufort and Chukchi Seas to the north, the Bering Sea to the west, and the Gulf of Alaska to the South.[641] In addition to over 33,000 miles of shoreline (more than 50% of the entire U.S. coastline)[642], Alaska has more than 3,000 rivers, including the major interior river systems of the Yukon and the Kuskokwim Rivers.[643] Many Alaska Native communities reside near the sea or river waters; waters on which they rely for hunting, fishing, and gathering wild plants for food.[644] These sustenance activities are deeply imbedded into the Alaska Natives' lives and promote the basic values of their culture - "generosity, respect for elders, self-esteem for the successful hunters, and community cooperation."[645] However, "[w]hile villages on Alaska's shorelines and river banks provide Alaska Natives with access to food, transportation, and recreational and cultural benefits, these locations also present dangers to the inhabitants."[646]

(b) Flooding and Erosion

Flooding and erosion are the biggest threats to many Alaska Native villages imposed by climate change, with some villages losing up to 50 to 75 feet of land each year.[647] According to the Alaska Division of Homeland Security and Emergency Management, as of 2009, 228 flooding events had led to state disaster declarations for 119 different Alaska communities since 1978.[648] The frequency and severity of these events are increasing and climate change worsens. In 2009, the U.S. Government Accountability Office (GAO) reported about 40 percent of those flooding disasters occurred between 2000 and 2008, "with 23 occurring in 2005, the worst year on record."[649]

One reason for such significant flooding and erosion is the thawing of permafrost, which is a consequence of rising temperatures.[650] Thawing permafrost causes village shorelines and riverbanks to slump and erode, which threatens homes and infrastructure.[651] Rising temperatures also threaten the sea ice that forms along the western and northern coasts of Alaska; as temperatures rise, sea ice loses thickness, extent, and duration, which leaves shorelines more

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[641] GAO 2009, *supra* note 639, at 4.
[642] ALASKA.ORG, *How Big is Alaska?*, http://www.alaska.org/how-big-is-alaska/Texas.
[643] GAO 2009, *supra* note 639, at 4.
[644] *Id.* at 6.
[645] *Id.*
[646] *Id.*
[647] Jess Colarossi, *This Community in Alaska is Relocating Because of Climate Change*, CLIMATE PROGRESS (Oct. 6, 2015), https://thinkprogress.org/this-community-in-alaska-is-relocating-because-of-climate-change-86d401273eb/.
[648] GAO 2009, *supra* note 639, at 6-7.
[649] *Id.* at 7.
[650] *Id.*, see also *supra* B.1.3 (section on melting and permafrost).
[651] GAO 2009, *supra* note 639, at 7.

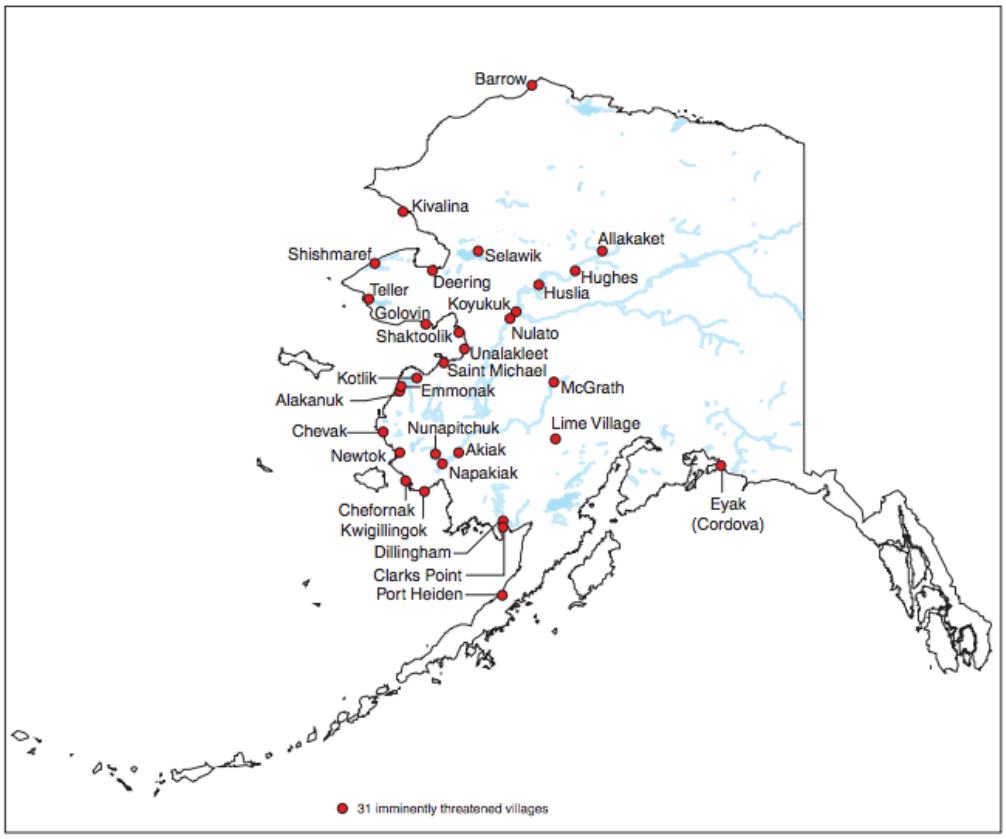
vulnerable to waves and storm surges.[652] The loss of sea ice, along with thawing permafrost, accelerates the erosion threatening Alaska Native villages.[653]

In 2003, GAO reported that 184 out of 213, or 86 percent of Alaska Native villages experience climate change impacts of flooding and erosion,[654] and found that four of the nine villages assessed in the report – Kivalina, Koyukuk, Netwok, and Shishmaref – were in imminent threat of flooding and erosion.[655] Fourteen years later, these villages remain in imminent danger of losing their Native land to flooding and erosion due to a lack of sufficient funding for the relocation process, a relocation site, and partnering with governmental organizations.[656] In fact, by 2009 the number of villages identified as "imminently threatened by flooding and erosion" had risen from four to thirty-one.[657] (See figure 4 from GAO 2009 below.)

Figure 4:

[652] *Id.*
[653] *Id.*
[654] GAO 2003, *supra* note 639, at 2.
[655] *Id.* at 27.
[656] *See* UNIV. OREGON TRIBAL CLIMATE CHANGE PROJECT, *Climate Change: Realities of Relocation for Alaska Native Village*, UNIV. OREGON 1 (April 2011), http://tribalclimate.uoregon.edu/files/2010/11/AlaskaRelocation_04-13-11.pdf; *see also* John D. Sutter, *Tragedy of a City Built on Ice*, CNN (Mar. 29, 2017), http://www.cnn.com/2017/03/29/us/sutter-shishmaref-esau-tragedy; Michael Walsh, *This Tiny Alaska Town Is Leading the Way on Climate Change*, YAHOO! NEWS (Apr. 21, 2017), https://www.yahoo.com/news/alaskan-village-fights-survival-island-disappears-170730957 html.
[657] GAO 2009, *supra* note 639, at 12.

Figure 4: Locations of 31 Alaska Native Villages Imminently Threatened by Flooding and Erosion



Sources: GAO (analysis); Pitney Bowes Business Insight (map).

(c) Relocation

For Alaska Native communities, relocating an entire community from its land "represents breaking from uniquely adapted traditions that took thousands of years to develop."[658] Alaska Native peoples "continue to have a deep relationship with ancestral homelands for sustenance, religious communion and comfort, and to maintain the strength of personal and inter-familiar identities. Through language, songs, and ceremonies, tribal people continue to honor sacred springs, ancestral burial places, and other places where ancestral communities remain alive."[659] The spiritual connection between many Native Nations and their surrounding environment is crucial to the sovereignty of these nations and to individual personhood.[660] Relocation can sever these deep and long-standing honored connections, forever changing personal and cultural identities in the process.[661]

[658] UNIV. OREGON TRIBAL CLIMATE CHANGE PROJECT, *supra* note 656, at 1.
[659] Mary Christina Wood & Zachary Welcker, *Tribes as Trustees Again (Part I): The Emerging Tribal Role in the Conservation Trust Movement*, 32 HARV. ENVTL. L. REV. 373, 381 (2008), http://www.klamathbasincrisis.org/whosewho/tribestrusteesBecky.pdf.
[660] *Id.* at 424.
[661] It should be noted, however, that relocation of Native communities is an issue far broader and more complex than can be addressed here, as we examine it solely through the climate change impacts lens. For a fuller examination of relocation, see, e.g., Emilie S. Cameron, *Securing Indigenous Politics: A Critique of the Vulnerability and*

Relocation is extremely costly. The U.S. Army Corps of Engineers has estimated the cost of relocation in the $100-200 million range per village.[662] But staying is costly, too. As protective ice barriers melt and coastlines erode, coastal villages find themselves in need of costly infrastructure repair.[663] Unfortunately, the fact that future relocation is inevitable (unjustly) works against villages in need of financial assistance for immediate crucial infrastructure support – leaving villages stuck in a "catch-22".[664] Nevertheless, despite the devastating psychological, culture and financial costs, climate change impacts have left residents of these villages little choice but to begin the relocation process.[665] Three villages have started working to find a suitable relocation site with local agencies: Shishmaref, Newtok, and Kivalina.[666]

(i) *Shishmaref*

The village of Shishmaref, with a population of 563,[667] is called the "most extreme example of global warming on the planet."[668] Village residents are directly affected by climate change and may be the world's first climate change refugees.[669] Shishmaref is located on the western coast of Alaska, on a barrier island of the Chukchi Sea.[670] The village has been inhabited for over 4,000 years, and has always depended on the surrounding ice for food, water, and protection against storm surges.[671] In the last few decades, Shishmaref has lost over 40% of the surrounding sea ice, which has led to evacuations for more than 10 homes in the village.[672]

Adaptation Approach to the Human Dimensions of Climate Change in the Canadian Arctic, GLOBAL ENVIRONMENTAL CHANGE (Feb. 2012), http://www.sciencedirect.com/science/article/pii/S0959378011001919 (focusing in particular on the exclusion of colonialism from the study of human vulnerability and adaptation to climatic change, the framing of Indigenous peoples and communities in terms of the local and the traditional, and the ways in which efforts to improve the lives of northern Indigenous peoples risk perpetuating colonial relations).

[662] UNIV. OREGON TRIBAL CLIMATE CHANGE PROJECT, *supra* note 656, at 1–2 (estimating cost of relocating Kivalina: $95-$125 million, Shishmaref: $100-$200 million, and Newtok: $80-$130 million).

[663] GAO 2009, *supra* note 639, at 1 ("Flooding and erosion have caused millions of dollars of property damage in these remote villages, and in some cases, poses imminent threats to lives, homes, and infrastructure.").

[664] Erica Goode, *A Wrenching Choice for Alaska Towns in the Path of Climate Change*, N.Y. TIMES (Nov. 29, 2016), http://www.nytimes.com/interactive/2016/11/29/science/alaska-global-warming html ("Even announcing the intention to relocate can scuttle a community's request for financing. Some years ago, when Shaktoolik indicated on a grant proposal that it was hoping to move, it lost funds for its clinic, said Isabel Jackson, the city clerk.").

[665] It should be further noted that while these communities may be forced to relocate, they are also seizing relocation as an opportunity to represent their own vision of their future and to make plans for how to manifest those plans into village designs that take into account aspirations for more self-determined futures. *See* Re-Locate, *Frontline Communities Are Making the Post-Climate World*, CREATIVE TIME REPORTS (Dec. 11, 2015), http://creativetimereports.org/2015/12/11/relocate-kivalina.

[666] GAO 2009, *supra* note 639, at 27.

[667] *Population Demographics for Shishmaref, Alaska for 2016 and 2017*, SUBURBAN STATS., https://suburbanstats.org/population/alaska/how-many-people-live-in-shishmaref.

[668] David Willis, *Sea Engulfing Alaskan Village*, BBC NEWS (July 30, 2004), http://news.bbc.co.uk/2/hi/europe/3940399.stm.

[669] David James, *More Than Global Warming Afflicts Endangered Shishmaref,* ALASKA DISPATCH NEWS (Mar. 27, 2016), http://www.adn.com/books/article/more-global-warming-afflicts-endangered-shishmaref/2016/03/27.

[670] UNIV. OREGON TRIBAL CLIMATE CHANGE PROJECT, *supra* note 656, at 3.

[671] *Id.*

[672] *Id.*

Rising temperatures, and the consequential reduction in sea ice and thawing permafrost, have exposed the village to erosion from Arctic storms, which are becoming increasingly serious.[673] The villages' homes and infrastructure are threatened by this erosion, which has taken as much as 15 meters of land overnight in one storm.[674] Shishmaref has developed erosion control structures to protect the village from storm surges, now that surrounding sea ice—which used to offer protection—is no longer present.[675] In 2001, the State spent approximately $100,000 to install sand-filled gabions along the worst hit shoreline.[676] In 2004 and 2005, the Bureau of Indian Affairs, the U.S. Army Corps of Engineers, and the community, installed over 600 feet of shoreline protection.[677]

Also in 2001, Shishmaref started exploring the possibility of relocation, and in 2002 the Shishmaref Erosion and Relocation Coalition was formed by the governing members of the city, Indian Reorganization Council, and the Shishmaref Native Corporation Board of Directors.[678] The Shishmaref Erosion and Relocation Coalition developed a strategic relocation plan in 2001, which was funded by the Alaska Division of Emergency Services for a cost of $50,000.[679] Although the plan recognized steps that needed to be taken in order to relocate the village, it did not "identify or recommend a new village site."[680] In 2004, the Shishmaref Erosion and Relocation Coalition selected Tin Creek as the community's relocation site.[681] However, in 2008 after six studies conducted over four years, the Alaska Department of Transportation and Public Facilities determined that Tin Creek was unsuitable as a relocation site due to the thawing permafrost the land sits on.[682] As of July 2015, the City of Shishmaref was working on a Site Selection Feasibility Study to allow the community to "identify a new village location that is safe, stable, and sustainable."[683]

In 2009, the Alaska Climate Change Impact Mitigation Program granted the City of Shishmaref money to conduct a Shishmaref Relocation Plan Update.[684] The report indicated that in 2010, the cost of relocation could exceed $214 million over 15 years; the estimated financial cost to not relocate could exceed $112 million.[685] In March 2009, the Immediate Action Workgroup, appointed by former-Governor Sarah Palin, found that "Shishmaref has been threatened by erosion for many years with recent increases due to the lack of sea ice during the

[673] Hassol, *supra* note 354, at 80.
[674] *Id*.
[675] *Shishmaref Strategic Management Plan* (Draft), 9 (Aug. 4, 2015), https://www.commerce.alaska.gov/web/Portals/4/pub/091615_DRAFT_SMP_Background_Report_Shishmaref.pdf.
[676] *Id*.
[677] *Id*.
[678] UNIV. OREGON TRIBAL CLIMATE CHANGE PROJECT, *supra* note 656, at 3.
[679] *Shishmaref Strategic Management Plan*, *supra* note 675, at 9.
[680] *Id*.
[681] *Id.* at 10.
[682] *Id*.
[683] *Id*.
[684] *Id*.
[685] *Id*.

fall storm season."[686] According to the Immediate Action Workgroup's report, funding is needed to continue Shishmaref's relocation effort.[687]

On August 18, 2016, Shishmaref residents voted 89 to 78 to relocate their village to "one of two sites on the mainland about five miles away."[688] However, the community has no money to fund the move.[689] Further, since the only feasible relocation destinations are inland, "hunters and fishers would not be able to access the sea easily" such that "[s]ome people in the community – particularly elders – believe the move threatens the tribe's Inupiat identity."[690]

(ii) *Newtok*

"*Not that long ago the water was far from our village and could not be easily seen from our homes. Today the weather is changing and is slowly taking away our village. Our boardwalks are warped, some of our buildings tilt, the land is sinking and falling away, and the water is close to our homes. Our infrastructure that supports our village is compromised and affecting the health and wellbeing of our community members, especially our children."*
Moses Carl, Newtok, 2012[691]

The village of Newtok has been referred to as "the sinking village" due to severe flooding, erosion, and rising seas, and as a "possible national model" for moving villages threatened by climate change.[692] The village has already lost its barge landing, sewage lagoon, and landfill to erosion and thawing permafrost, expects to lose its source of drinking water in 2017, and even the school, which sits atop 20-foot pilings and is the highest place in the village, could be underwater by 2020.[693] The Yup'ik people of Newtok have lived on the Yukon-Kushkokwim

[686] Immediate Action Workgroup, *Recommendations to the Governor's Subcabinet on Climate Change*, STATE OF ALASKA 55 (Mar. 2009), http://climatechange.alaska.gov/docs/iaw_finalrpt_12mar09.pdf.
[687] *Id.*
[688] *See* Christopher Mele & Daniel Victor, *Reeling from Effects of Climate Change, Alaskan Village Votes to Relocate*, N.Y. TIMES (Aug. 20, 2016), http://www.nytimes.com/2016/08/20/us/shishmaref-alaska-elocate-vote-climate-change html.
[689] Lisa Demer, *Shishmaref Votes to Relocate from Eroding Barrier Island to Mainland,* ALASKA DISPATCH NEWS (Aug. 18, 2016), https://www.adn.com/alaska-news/2016/08/18/eroding-village-of-shishmaref-votes-in-favor-of-relocating-to-mainland-a-key-step; John D. Scutter, *Tragedy of a Village Built on Ice*, CNN (Mar. 29, 2017), http://www.cnn.com/2017/03/29/us/sutter-shishmaref-esau-tragedy.
[690] Scutter, *supra* note 689.
[691] Quote from Moses Carl, a member of the Yup'ik Eskimo community who lives in Newtok, AK, given to the Alaska Department of Commerce and Community and Economic Development. Alaska Department of Commerce and Community and Economic Development, *2012: Strategic Management Plan: Newtok to Mertarvik* (2012) reprinted in Chapin, *supra* note 355, at 518; *see also* Community of Newtok and the Newtok Planning Group, *Mertarvik - Relocation Report: Newtok to Mertarvik*, STATE OF AK DEP'T OF COMMERCE, COMMUNITY, & ECONOMIC DEVELOPMENT DIVISION OF COMMUNITY AND REGIONAL AFFAIRS, at 2 (Aug. 2011), https://www.commerce.alaska.gov/web/Portals/4/pub/Mertarvik_Relocation_Report_final.pdf.
[692] Colarossi, *supra* note 647.
[693] *Id;* Rachel Waldholz, *Alaska Village, Citing to Climate Change, Seeks Disaster Relief in Order to Relocate*, NPR (Jan. 10, 2017), http://www.npr.org/2017/01/10/509176361/alaskan-village-citing-climate-change-seeks-disaster-relief-in-order-to-relocate.

Delta in western Alaska for over 2,000 years.[694] The village of Newtok is the "only one of Alaska's several threatened communities that has begun a physical move,"[695] however, the move is not far along at all.[696]

Located over permafrost, which has been thawing due to rising temperatures, Newtok has experienced a loss of about 50 to 75 feet of land per year due to climate change induced erosion.[697] The thawing permafrost is "sinking, knocking down homes and villages out of alignment."[698] The village is encircled by the Ninglick River (which is tidally influenced and connects Baird Inlet from the Bering Sea), whose raging waters have been "eating the land out from under the village,"[699] causing Newtok to lose an average of 72 feet of land per year, with the highest observed rate at 300 feet per year.[700] The Newtok River, once a free-flowing river, was captured by the Ninglick River in 1996 "nearly overnight" making the village "more susceptible to storm surges on the Ninglick due to the direct hydrologic connection."[701] The Newtok River became a slough, making it nearly impossible for commercial vessels to navigate to the village, as they previously had.[702] The erosion in Newtok has essentially made it more isolated than ever.[703]

Newtok is also extremely prone to floods due to powerful storm surges that can "raise tide levels 10 to 15 feet above normal and severe flood events."[704] Between 2002 and 2013, the village of Newtok experienced seven floods, six of which were federally declared disasters.[705] The storms led to severe impacts, including flooded water supplies, raw sewage spread throughout the village, displaced residents, destroyed subsistence food storage, and the shutdown of essential utilities.[706] In fact, the raging "20-year storm" of 2005 temporarily turned the village into an island.[707]

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[694] Lisa Demer, *The Creep of Climate Change*, AK DISPATCH NEWS (Aug. 29, 2015), http://www.adn.com/rural-alaska/article/threatened-newtok-not-waiting-disintegrating-village-stages-move-new-site/2015/08/30.
[695] Associated Press, *Alaska Seeks Federal Money to Move a Village Threatened by Climate Change*, N.Y. TIMES (Oct. 3, 2015), https://www.nytimes.com/2015/10/04/us/alaska-seeks-federal-money-to-move-a-village-threatened-by-climate-change.html.
[696] Alana Semuels, *The Village That Will Be Swept Away*, ATLANTIC (Aug. 30, 2015), http://www.theatlantic.com/business/archive/2015/08/alaska-village-climate-change/402604.
[697] Colarossi, *supra* note 647; *see also* Cochran, *supra* note 629, at 53.
[698] Asociated Press, *supra* note 695.
[699] Colarossi, *supra* note 647
[700] Sally Russel Cox, *Strengthening Local Resilience Through Community-Based Adaptation Efforts*, RIGHTS, RESILIENCE AND COMMUNITY-BASED ADAPTATION WORKSHOP, ALASKA DIVISION OF COMMUNITY AND REGIONAL AFFAIRS (Sept. 20, 2016), https://www.commerce.alaska.gov/web/Portals/4/pub/Rights_Resilience_Community-Based_Adaptation_Workshop.pdf.
[701] Community of Newtok and the Newtok Planning Group, *supra* note 691, at 6.
[702] *Id*.
[703] Semuels, *supra* note 696.
[704] Alaska Department of Commerce and Community and Economic Development, *supra* note 691, at 7.
[705] Phil Daquila, *Losing Place and Losing Hope*, NATURAL HAZARDS CENTER (Apr. 28, 2016), https://hazards.colorado.edu/article/losing-place-and-losing-hope-newtok-s-challenging-journey-to-higher-ground.
[706] *Id*.
[707] Semuels, *supra* note 696.

Severe flooding and erosion have impacted the health and safety of Newtok village residents.[708] "Flood waters wash honey bucket waste from the Newtok River back into the village while the risk of permanent salination of the community's drinking water source potentially poses the most immediate threat to the community."[709] Further, between 1994 and 2004, almost 30 percent of infants in Newtok were hospitalized due to lower respiratory tract infections, which were linked to the substandard sanitation conditions, including "inadequate potable water for drinking and personal hygiene, human waste contamination, and household crowding."[710] The lack of adequate health and safety measures in Newtok can be explained by federal and state agencies' divestment driven by a "desire not to waste funds and maintaining infrastructure in the existing village when the community intends to move."[711]

Newtok residents are extremely connected to their land, and the village has already moved once in 1949, from Old Kealavik to its current site, to "avoid flooding and [to] find suitable ground for a new school."[712] The current relocation process for Newtok began in 1994, and the Newtok residents had selected Mertarvik as their relocation site in 1996.[713] After years of negotiation, Newtok Native Corporation acquired Mertarvik's 10,943 acres from the U.S. Department of Interior on November 17, 2003.[714] In 2006, the Newtok Planning Group (NPG) was established by the Newtok community, government agencies, and non-governmental organizations, and has been identified as "a model for local community, state, and federal partnerships to address complex issues."[715] NPG works "across agencies to secure funding and establish a framework and strategy for pushing the relocation process forward."[716] However, NPG has faced many challenges in the relocation process, including a lack of ample funding, sufficient guidance, and a reliable agency to take charge.[717]

Despite the many challenges amidst the relocation process, progress has been made towards creating a new life for the climate change refugees of Newtok. NPG, along with the Governor's Sub-Cabinet on Climate Change's Immediate Action Work Group, obtained funding for the "community for the development of several initial or groundwork laying infrastructure projects at Mertarvik."[718] Newtok residents have secured funding towards building new structures like roads, a clinic, an airport, and an emergency evacuation center, as well as transporting structurally sound buildings and homes.[719] So far, about $27 million has been

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[708] *Id.*; Alaska Department of Commerce and Community and Economic Development, *supra* note 691, at 1; Immediate Action Workgroup, *supra* note 686, at 1; *see also* Cochran, *supra* note 629, at 53.
[709] Alaska Department of Commerce and Community and Economic Development, *supra* note 691, at 7.
[710] Daquila, *supra* note 62.
[711] Alaska Department of Commerce and Community and Economic Development, *supra* note 691, at 7.
[712] *Id.* at 7.
[713] UNIV. OREGON TRIBAL CLIMATE CHANGE PROJECT, *supra* note 656, at 3.
[714] Alaska Department of Commerce and Community and Economic Development, *supra* note 691, at 8.
[715] Immediate Action Workgroup, *supra* note 686, at 6; *see also* UNIV. OREGON TRIBAL CLIMATE CHANGE PROJECT, *supra* note 656, at 6.
[716] Alaska Department of Commerce and Community and Economic Development, *supra* note 691, at 9.
[717] *Id.*; *see also* Semuels, *supra* note 696; Cochran, *supra* note 629, at 53.
[718] Alaska Department of Commerce and Community and Economic Development, *supra* note 691, at 9.
[719] Anna Rose MacArthur, *Federal Grant Helps Newtok Village Relocate Due to Erosion of Ningliq River*, ALASKA PUBLIC (May 19, 2016), http://www.alaskapublic.org/2016/05/19/federal-grant-helps-newtok-village-relocate-due-to-erosion-of-ningliq-river.

invested in Mertarvik and in needed investments in Newtok.[720] Initial infrastructure projects in Mertarvik include the "construction of a barge landing, initial roads, the Mertarvik Evacuation Center, two production water wells, establishment of a construction camp, the planning stages of the future airport, and development of a local gravel source."[721]

Although some funding has already been secured and several houses have already been built, the Army Corps of Engineers has estimated the cost of relocation at $80 million to $130 million to relocate and establish crucial infrastructure alone.[722] Like Shishmaref, Newtok lacks sufficient funding for relocation.[723] "In an unprecedented test case," Newtok has asked the president to declare the climate impacts on the village an official disaster in hopes of "unlocking the tens of millions of dollars needed to relocate the entire community."[724] If funding is not secured, community members could be "forced to scatter, with some even moving 500 miles away to Anchorage," endangering the "community, culture, Yup'ik language and identity."[725]

Although there are many obstacles in the relocation process, Newtok residents prove that relocation can "strengthen a community's relationships and core values, enhance the skills and capacity of its people, and spark a return to the subsistence lifestyle that is so important to the past and the future of Newtok's people and culture."[726]

(iii) *Kivalina*

The village of Kivalina is "quickly losing the ice that governs life for its 400 residents."[727] Kivalina is located on a barrier island in Northwestern Alaska along the Chukchi Sea, 83 miles above the Arctic circle.[728] The Iñupiat residents of Kivalina[729] see the impacts of climate change on a daily basis "felt in drastic changes to weather, loss of traditional means of sustenance like whale hunting, and the literal vanishing of land."[730] Climate change impacts are so severe that the U.S. Army Corps of Engineers (USACE) has predicted Kivalina will "be completely uninhabitable by 2025, a victim of melting ice, coastal erosion and rising sea levels."[731]

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[720] Alaska Department of Commerce and Community and Economic Development, *supra* note 691, at 10.
[721] *Id.*
[722] Waldholz, *supra* note 693.
[723] *Id.*
[724] *Id.*
[725] *Id.*
[726] Alaska Department of Commerce and Community and Economic Development, *supra* note 691, at 4.
[727] UNIV. OREGON TRIBAL CLIMATE CHANGE PROJECT, *supra* note 656, at 3.
[728] Chris Mooney, *The Remote Alaskan Village that Needs to be Relocated Due to Climate Change*, WASH. POST (Feb. 24, 2015), https://www.washingtonpost.com/news/energy-environment/wp/2015/02/24/the-remote-alaskan-village-that-needs-to-be-relocated-due-to-climate-change; *see also* Carol Kuruvilla, *Climate Change Will Cause Alaskan Villages to Vanish Water Within 10 Years*, NY DAILY NEWS (June 30, 2013), http://www.nydailynews.com/news/national/alaskan-village-vanish-water-decade-scientists-article-1.1412920.
[729] Lawrence C. Hamilton et al., *Climigration? Population and Climate Change in Arctic Alaska*, 38 POPULATION & ENVIRONMENT 115, 119 (June 23, 2016), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5080311/pdf/11111_2016_Article_259.pdf.
[730] Mooney, *supra* note 728.
[731] Kuruvilla, *supra* note 728; Hamilton, *supra* note 729, at 119; *see also* U.S. Army Corps of Engineers, Alaska District, *Kivalina, Alaska Relocation Planning Project Master Plan* ES-2 (June 2006), http://www.poa.usace.army.mil/Portals/34/docs/civilworks/reports/KivalinaMasterPlanMainReportJune2006.pdf

Anthropogenic climate change has resulted in thinning Arctic sea ice, which has become a primary risk to Kivalina residents.[732] The melting sea ice, which is visible from the sky, has replaced "multiyear" ice with "younger" ice, which is thinner and more fragile.[733] The residents of Kivalina have relied on a thick build-up of sea ice to protect the village from erosion and storms.[734] As temperatures rise, the sea ice is "forming later and melting earlier," leaving the village unprotected from winter storms that are "devour[ing] the island at alarmingly fast rates – up to 70 feet of land at a time."[735] The United States Army Corps of Engineers has tried to mitigate the impacts of erosion in Kivalina; in 2008, a seawall was built to protect the village from the storms, but it is only a "temporary solution,"[736] and even with the sea wall, residents were forced to temporarily evacuate Kivalina after a 2011 storm.[737]

Like other Native villages threatened by climate change, "Kivalina's environmental problems aren't restricted to the coast."[738] As permafrost thaws "the nearby Wulik River washes away large chunks of streambank, and increased river sediment has caused difficulty treating the community water supply."[739] Climate change has had profound impacts on the availability of food and community's ability to hunt and harvest the meat, fruit, and vegetables on which they rely for subsistence as well as the ability to store food safety.[740]

Due to the severe climate change impacts experienced by the people of Kivalina, and their deep connection to the land, Kivalina residents remain "torn between tradition and a deeply uncertain future."[741] The longer it takes the village of Kivalina to relocate, the more expensive it will be.[742] The village of Kivalina voted to relocate in 1992[743], however, state budget constraints have slowed the progress of preliminary studies.[744] Relocation has become imminent and "the need for viable futures is urgent."[745]

(d) Food and Water Scarcity and Safety

("The 'do nothing' option will result in the current village site being overtopped with water during a storm or eroded away over time, and ultimately having to be abandoned.").
[732] Mooney, *supra* note 728.
[733] *Id*.
[734] Kuruvilla, *supra* note 728.
[735] *Id*.
[736] *Id*.; Mooney, *supra* note 728.
[737] Kuruvilla, *supra* note 728.
[738] U.S. Climate Resilience Toolkit, *Relocating Kivalina*, NOAA, https://toolkit.climate.gov/taking-action/relocating-kivalina (last updated January 17, 2017).
[739] *Id*.
[740] *Id*.
[741] Mooney, *supra* note 728.
[742] U.S. Climate Resilience Toolkit, *supra* note 738; *see also* Kuruvilla, *supra* note 728; *see also* Mooney, *supra* note 728.
[743] Kuruvilla, *supra* note 728.
[744] U.S. Climate Resilience Toolkit, *supra* note 738.
[745] *Re-Locate Kivalina: Overview*, THREE DEGREES WARMER (July 15, 2015), http://threedegreeswarmer.org/wp-content/uploads/2015/07/Screen-Shot-2015-07-15-at-2.28.38-PM.png.

In 2001, on behalf of the U.S. Global Change Research Program (USGCRP), Dr. Margaret Leinen testified before the Committee on Appropriations, United States Senate, at a Special Hearing on climate change held in Fairbanks. Dr. Leinen's testimony outlined USGCRP expert findings regarding climate change impacts on Alaska, including:

> Increased Stress on Subsistence Livelihoods —Subsistence practices are probably more important in Alaska than any other state. The subsistence harvest by rural residents is about 43 million pounds of food annually, or about 375 pounds per person. The significance of such practices in Alaska goes beyond the provision of food. Subsistence activities are also associated with harvests making important contributions to health, culture, and identity. Climate changes in Alaska are already causing serious harm to subsistence livelihoods. Many local populations of marine mammals, fish, and seabirds have been reduced or displaced. Reduced snow cover, shorter river ice seasons, and permafrost thawing all obstruct travel and the harvest of wild food. Continued warming is likely to lead to further ecosystem changes.[746]

Alaska Native communities face increasingly diminishing hunting prospects for many of the marine mammals they rely upon for subsistence; "[a]s the ice melts or moves away early, walruses, seals, and polar bears move out of hunting range."[747] Additionally, arctic species relied upon by subsistence hunters have begun to diminish – victims of climate change: "The impacts to this ecosystem have affected populations of marine polar bears, caribou, walrus, and killer whales, all of which have great significance to the Native peoples who depend on those species for their survival….Not only are the animals and lake fish disappearing, but hunters face hazardous conditions, such as the danger of falling through thin sea ice."[748] Further, the "dietary and economic well-being" of these communities has been "directly affected" by the recent declines in salmon and other fish that travel up river to spawn – which account for 60 percent of Alaska Natives' subsistence resources.[749]

Alaska Native communities have observed changes in the health and behavior of caribou, another key subsistence species, as climate change has worsened. These changes which negatively affect subsistence hunting.[750] For instance, global warming has resulted in decreases

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[746] Hearing before the Senate Committee on Appropriations, 107th Cong., 55 (May 29, 2001), https://www.gpo.gov/fdsys/pkg/CHRG-107shrg76969/pdf/CHRG-107shrg76969.pdf.
[747] GAO Report to Cong. Comm., GAO-09-551, *Alaskan Native Villages: Limited Progress Has Been Made on Relocating Villages Threatened by Flooding and Erosion* 7–8 (2009), http://www.gao.gov/assets/300/290468.pdf; *see also* Cochran, *supra* note 629, at 52–53.
[748] *See* Rebecca Tsosie, *Indigenous People and Environmental Justice: The Impact of Climate Change*, 78 U. COLO. L. REV. 1625, 1640 (2007); Gavin Stern, *The Great Arctic Experiment: Climate Change is Affecting the Region's Estuaries, Politics, and What It Means To Go Home*. 350 SCIENCE 520–21 (Oct. 30, 2015), http://science.sciencemag.org/content/350/6260/520 full.
[749] Hassol, *supra* note 354, at 119.
[750] U.S. Climate Resilience Toolkit, *supra* note 738; Larry D. Hinzman et al., *Evidence and Implications of Recent Climate Change in Northern Alaska and Other Arctic Regions*, 72 CLIMATIC CHANGE 252, 286 (2005), https://www.fs.fed.us/pnw/pubs/journals/pnw_2005_hinzman001.pdf; Gabriel Halas, *Caribou Migration, Subsistence Hunting, and User Group Conflicts in Northwest Alaska: A traditional Knowledge Perspective*, Masters Thesis (Aug. 2015), available for download at https://scholarworks.alaska.edu/handle/11122/6090.

in caribou populations[751] as well as changes in the plant community and timing of vegetation on which caribou forage, leading to changing migration patterns.[752] For instance, in the absence of the sea ice, which is melting earlier and earlier in the season as climate change progresses, communities residing on barrier islands (such as Shishmaref), can no longer travel to the mainland to hunt moose and caribou, as they normally would by early-November.[753]

Moreover, warming conditions are causing traditional underground ice cellars to melt.[754] These traditional underground ice cellars, which are cut directly into the permafrost, have long been used to store food.[755] "However, when the permafrost melts, the hard-won caribou, seal, and other meat stored in these cellars can rot and become unusable."[756] This inability to store meat "compounds two other problems with these traditional food sources: the animals have grown more scarce, and collecting them has become more difficult and dangerous because of melting sea ice and flooded lands."[757]

The thawing of ice cellars cause food contamination and contributed to the loss of traditional foods in Native communities' diets, which are already being made scarce by climate change.[758] A shift from traditional food to a western diet, "increases dependence on non-traditional, expensive, and often less-healthy store-bought foods."[759] Concern about contaminants in traditional foods also lead a shift to a western diet, which is "associated with increases in 'modern diseases' such as obesity, diabetes, cardiovascular disease, and cancer and contributes to negative social, cultural, economic, and nutritional effects."[760]

Alaskan Native communities are particularly at risk to the impacts of anthropogenic climate change on access to safe drinking water:

> Rural Alaska Native communities both in the Arctic and elsewhere in Alaska depend on groundwater (66%), lakes and reservoirs (20%) and rivers and creeks (14%) for their water supply. Little information is available on changes to Alaska Native groundwater supplies, however, surface water sources and water supply infrastructure are being

[751] *See* Struzik, *supra* note 568.
[752] U.S. Climate Resilience Toolkit, *supra* note 738; Michael Brubaker, Rej Chavan, *Climate Change in Kiana, Alaska: Strategies for Community Health*, ALASKA NATIVE TRIBAL HEALTH CONSORTIUM (Oct. 2011), at 4–5, 7–8, 11, 23–26, http://anthc.org/wp-content/uploads/2016/01/CCH_AR_102011_Climate-Change-in-Kiana.pdf; *see also Global Warming Threatens Caribou*, OREGON PUBLIC BROADCASTING, https://opb.pbslearningmedia.org/resource/ean08.sci.ess.watcyc.caribou/global-warming-threatens-caribou/#.WQ0USFKZPOQ.
[753] Hassol, *supra* note 354, at 80.
[754] U.S. Climate Resilience Toolkit, *Inupiaq Work to Preserve Food and Traditions on Alaska's North Slope,* NOAA, https://toolkit.climate.gov/case-studies/iñupiaq-work-preserve-food-and-traditions-alaskas-north-slope (last updated January 17, 2017); *see also* Cochran, *supra* note 629, at 52.
[755] U.S. Climate Resilience Toolkit, *supra* note 754.
[756] *Id.*
[757] *Id.*
[758] Cochran, *supra* note 629, at 52.
[759] *Id.*
[760] *Id.*

> dramatically affected by climate changes. Algal blooms are increasing in lakes and rivers due to warmer temperatures, and in villages, like Point Hope, they are causing significant increases in treatment time and costs. Beavers, which can carry giardia, are occupying rivers in northern Alaska for the first time since the last ice age and are an example of shifting wildlife acting as vectors for waterborne diseases. As permafrost thaws in various areas of Alaska, the ground can absorb more water, and some lake levels are decreasing or lakes are draining entirely, causing water supply problems. Erosion driven by permafrost thawing can cause high river turbidity levels, resulting in boil water notices and increased risk of waterborne disease. Extreme precipitation events can lead to flood-related contamination and high turbidity levels that can overwhelm water treatment systems. Subsidence due to permafrost thawing and erosion are causing widespread physical damage to water infrastructure, sometimes interrupting services for months.[761]

(e) Cultural Practices and Heritage Loss

In addition to sustaining the economic and nutritional viability of many Alaska Native communities, Alaska's Arctic and sub-Arctic living resources provide a basis for social identity, spiritual life, and cultural survival.[762] Alaska Native communities possess a deep spiritual connection with land and the environment.[763] Alaska Native's "strong sense of place and sense of connection to the organisms that inhabit [their land] makes climate change a much deeper and more personal impact" than to communities who do not have that special connection to their environment.[764]

Due to high poverty rates in Alaska Native communities, high cost of fuel and commercial goods, and a lack of available jobs to provide a cash income, "indigenous people in rural Alaska depend directly on the local environment for food, transportation, and survival and have a strong need to understand and manage the consequences of climate change."[765] Alaska Natives are connected to the land their communities have lived on for generations through "observations,

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[761] K. Cozzetto et al., *Climate Change Impacts on the Water Resources of American Indians and Alaska Natives in the U.S.*, SPRINGER SCIENCE+BUSINESS MEDIA DODRECHT 9–10 (Aug. 30, 2013), https://greatbasinlcc.blob.core.windows net/media/Default/Webinar_Series/2013%20Cozzetto%20CC%20impats%20on%20Tribal%20Waters.pdf (citations omitted); Michael Brubaker *et al.*, Alaska Native Tribal Health Consortium, Center for Climate and Health, *Source Drinking Water Challenges Changes to an Arctic Tundra Lake*, CCH BULLETIN No. 2 (Oct. 19, 2009), *available at* http://anthc.org/wp-content/uploads/2016/01/CCH-Bulletin-No-2-Source-Drinking-Water-Challenges-Changes-Arctic-Tundra-Lake.pdf

[762] Hassol, *supra* note 354, at 94.

[763] Cochran, *supra* note 629, at 50; *see also* NATIONAL CONGRESS OF AMERICAN INDIANS, Resolution #EWS-06-2004 – *Supporting a National Mandatory Program to Reduce Climate Change Pollution and Promote Renewable Energy* (2006), http://www.ncai.org/attachments/Resolution_KSlvpcMnfSafhsDsxFnQcTDKMclEpNfvEPQFCsLlhonOXZrOOXu_EWS-06-004.pdf; Frank Pommersheim, *The Reservation as Place: A South Dakota Essay*, 34 S.D. L. REV. 246, 250 (1989).

[764] Cochran, *supra* note 629, at 50

[765] *Id*.

riddles, stories, dances, art, language, music, and traditions,"[766] which have each evolved in a climatic and ecological context to Native cultures.[767] When knowledgeable elders pass away, and climate alters the climatic and ecological context, Native cultures' relationship between their land and fellow plants and animals become vulnerable.[768]

As climate change alters the land and environment in which they live, many Alaska Native communities are faced with devastating impacts on their culture, spirituality and traditions, especially as land is literally lost to the elements.[769] As Kivalina tribal president Millie Hawley said, moving to another city, like Anchorage or Fairbanks "would be like asking us not to be a people anymore."[770]

7. Economic Impacts

Climate change poses profound and daunting threats to the State of Alaska, Alaskans, and the Alaskan economy. Economic and financial impacts are wide-ranging and span across all sectors of Alaskan life including healthcare, wildlife and fisheries management, disaster relief, infrastructure construction and repair, and energy development, among others.

Alaskan commercial fisheries were responsible for over $1.7 billion dollars in landings in 2014, totaling over $8 billion generated after accounting for sales, income, and value-added impacts.[771] Recreational fishing adds over $1 billion to this figure. Salmon, pollock, and crab are the primary prizes in the industry, accounting for $546 million, $400 million, and $238 million, respectively.[772] Alaska's fisheries face profound impacts associated with climate change and ocean acidification which may significantly affect their abundance, and accordingly, their contribution to the Alaskan economy (See sections VI.A.6, VI.B.4.b, VI.B.4.c supra). Indeed, fisheries revenues are expected to decrease globally by over 10%.[773]

Thawing permafrost, thermokarst, increasingly severe storms and weather, flooding and erosion, increasing freeze/thaw cycles, increasing wildfires, and other climate change impacts are likely to take severe economic tolls on Alaska's infrastructure. [774] Much of Alaska's

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[766] *Id.*
[767] *Id.*
[768] *Id.*
[769] *See* Wood & Welcker, *supra* note 659, at 423 ("Native cultures have been organized for thousands of years around Creation stories that tie their emergence to the land itself, so their collective knowledge of its caretaking can be thought of as encoded in their cultural DNA.").
[770] Maria L. La Ganga, *This is Climate Change: Alaskan Villagers Struggle as Island is Chewed up by the Sea*, L.A. TIMES (Aug. 30, 2015) http://www.latimes.com/nation/la-na-arctic-obama-20150830-story html.
[771] *Fisheries Economics of the United States, North Pacific Region, Alaska*, NOAA (2014) https://www.st nmfs.noaa.gov/Assets/economics/publications/FEUS/FEUS-2014/Report-and-chapters/FEUS-2014-FINAL-03-NPac-V2.pdf.
[772] *Id.*
[773] Vicky W. Y. Lam et al., *Projected Change in Global Fisheries Revenues Under Climate Change*, NATURE 6:32607 (Sept. 7, 2016), https://www nature.com/articles/srep32607.pdf.
[774] *See generally* Alaska Department of Environmental Conservation, *Alaska's Climate Change Strategy: Addressing Impacts in Alaska, Final Report Submitted by the Adaptation*

infrastructure is built on ice. Permafrost (continuous and discontinuous) underlies much of the state, and the thawing of that permafrost is costly for infrastructure and communities.[775] This occurs through frost heaving, melting, flooding, and temperature change. Indeed, thawing permafrost threatens many of Alaska's roadways, including the Alaska Highway, the "critical artery" between Alaska and the contiguous United States.[776] Impacts of thawing permafrost on the highway system represent "the biggest geotechnical problem" faced by Alaska's Department of Transportation.[777] In addition to causing buildings to tilt and runways to crack, thawing permafrost can cause sudden drainage of lakes when the ice-sealing liner thaws.[778] This can empty village-drinking water sources or cause sewage lagoons to leak.[779] Even in the absence of thawing, warming of permafrost can impact infrastructure. For example, a piling sitting in permafrost that has warmed from –4 to –1°C will lose 70% of its load capacity.[780] According to 2008 estimates, by 2030, climate change is expected to add 10–20% to the cost of repairing and maintaining state infrastructure, including roads, airports, and harbors, for a total of $3–6 billion.[781]

Climate-change-induced erosion is a pressing problem along many of Alaska's rivers and coasts. This is due to the thawing of permafrost bluffs, declining sea ice (which previously armored the shore for a larger fraction of the year), increasing sea surface temperatures, and more powerful storms. Flooding and erosion affect 84% of Alaska's 200+ Native villages, and climate change is accelerating their impacts.[782] A 2004 report from the Government Accountability Office identified 31 villages in "imminent danger."[783] Estimated costs for the three villages most in need of immediate relocation are $95–125 million for Kivalina, $100–200 million for Shishmaref, and $80–130 million for Newtok.[784] If similar costs hold for all those 31 villages, the total would be around $3 billion.

Climate change is also likely to have increasingly severe and dangerous effects on public health (See Secion VI.A.8, VI.B.5), impacting both the healthcare industry as well as the productivity of Alaskan workers. Moreover, repairs to basic sanitation infrastructure impacted by climate change will incur further economic costs.

Advisory Group to the Alaska Climate Change Sub-Cabinet: Chapter 4: Public Infrastructure (27 Jan. 2010), http://www.climatechange.alaska.gov/aag/docs/aag_Ch4_27Jan10.pdf.

[775] *Id*.

[776] Greg Quinn*, Climate Change is Hell on Alaska's Formerly Frozen Highways*, BLOOMBERG (Aug. 2, 2016), https://www.bloomberg.com/news/features/2016-08-02/the-alaskan-highway-is-literally-melting.

[777] *Id*.

[778] Henry Cole, Vayla Colonell, & David Esch, *The Economic Impact and Consequences of Global Climate Change on Alaska's Infrastructure*, University of Alaska, Fairbanks (October 1998), http://www.besis.uaf.edu/besis-oct98-report/Infrastructure-1.pdf.

[779] *Id*.

[780] *Id*.

[781] Peter H. Larsen et al., *Estimating Future Costs for Alaska Public Infrastructure at Risk From Climate Change*, 18 GLOBAL ENVIRONMENTAL CHANGE 442 (2008), http://www.sciencedirect.com/science/article/pii/S0959378008000216.

[782] GAO 2003, *supra* note 639.

[783] GAO 2009, *supra* note 639.

[784] Kathy Lynn and Ellen Donoghue, *Climate Change: Realities of Relocation for Alaska Native Villages*, TRIBAL CLIMATE CHANGE PROFILE PROJECT (April 13, 2011), http://tribalclimate.uoregon.edu/files/2010/11/AlaskaRelocation_04-13-11.pdf.

Climate change is projected to hamper even the operations of the oil and gas industry in Alaska. Although a longer open-water season in the ocean could facilitate oil exploration, thawing permafrost, increased difficulty of disposing of drilling muds in sumps, and shorter ice road seasons will make work on land more costly.[785]

By contrast, a plan to transition Alaska to 100% renewable energy by 2050 would save Alaskans money, create jobs, and reduce mortalities. Specifically, by 2050, the projected cost savings would be $27,060[786] per person, per year; nearly 30,000 long-term jobs would be created; .9 billion dollars in health care costs, and 84 deaths would be avoided every year. [787]

While some of the costs outlined above may be quantifiable in terms of their monetary value and impact to Alaska's economy, the true costs of climate change are utterly incalculable. No monetary sum can adequately reflect the value of the health of Alaskan communities, the species and rich biodiversity that form Alaska's legacy, or the traditions, stories, and sacred places of Alaska Natives communities, all of which are imperiled by anthropogenic climate change. Nor can any financial sum compensate for the emotional loss associated with the relocation of entire Native villages and divorce from traditional culture. No expression of financial significance can accurately encapsulate the value of Alaska's ecosystems and the rich sustenance they endow upon all Alaskans, present and future.

C. *The Best Climate Science Provides a Prescription for Restoring the Atmosphere, Stabilizing the Climate System, and Protecting the Oceans from Acidification and Warming*

To protect Earth's climate for present and future generations, we must restore Earth's energy balance. "The increased concentration of CO_2 and other GHGs in the atmosphere operates to reduce Earth's heat radiation to space, thus causing an energy imbalance – less energy going out than coming in. This imbalance causes Earth to heat-up until it again radiates as much energy to space as it absorbs from the sun."[788] The best climate science[789] shows that if the

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[785] Steven V. Kokelj et al., *Permafrost and Terrain Conditions at Northern Drilling-Mud Sumps: Impacts of Vegetation and Climate Change and the Management Implications*, 64 COLD REGIONS SCIENCE AND TECHNOLOGY 46–56; Øistein Harsem, Arne Eide, & Knut Heen, *Factors Influencing Future Oil and Gas Prospects in the Arctic* 39 ENERGY POLICY 8037 (Dec. 2011).

[786] The cost savings include electricity cost savings, air quality damage savings, and climate costs savings to the world.

[787] Mark Z. Jacobsen, et al., *100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for the 50 United States*, 8 ENERGY & ENVTL. SCI. 2093, 2106, 2108, 2111 (2015), https://web.stanford.edu/group/efmh/jacobson/Articles/I/USStatesWWS.pdf. ADEC has also acknowledged the economic feasibility and benefits of regulating climate change. *See* Section VII.C.3.

[788] Hansen 2016 Declaration, *supra* note 15, at ¶ 22.

[789] *See generally* Hansen, *Where Should Humanity Aim?*, *supra* note 133; James Hansen, et al., (2013) *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, 8 PLOS ONE 8 (Dec. 3, 2013), http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0081648; James Hansen, et al., *Ice Melt, Sea Level Rise and Superstorms: Evidence From Paleoclimate Data, Climate Modeling, and Modern Observations That 2°C*

planet once again sends as much energy into space as it absorbs from the sun, this will restore the planet's climate equilibrium.[790] Scientists have accurately calculated how Earth's energy balance will change if we reduce long-lived greenhouse gases such as CO_2.[791] Humans have altered Earth's energy balance[792] and are currently causing a planetary energy imbalance of approximately 0.6 Watts per square meter.[793] We would need to reduce atmospheric CO_2 concentrations to at least 350 ppm, in order to increase Earth's heat radiation into space by 0.6 Watts, if other long-lived gases stay the same as today.[794]

All of the states and countries of the world, including Alaska, must do their parts to reduce atmospheric CO_2 concentration to a maximum of 350 ppm to avoid the threats detailed herein, to avoid significant disturbance of physical and biological systems as a result of global climate change, and to achieve stabilization of the GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.[795]

The current science also shows that to protect Earth's natural systems, long-term average global surface heating should not exceed 1°C this century.[796] According to the current climate science, to prevent global heating greater than 1°C, concentrations of atmospheric CO_2 must decline to 350 ppm or less by the end of this century.[797] However, today's atmospheric CO_2 levels exceed 400 ppm and are rising.[798]

A target of keeping global surface heating to 2°C above pre-industrial temperatures, which approximately equates to an atmospheric CO_2 concentration of 450 ppm, cannot be

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Global Warming Could Be Dangerous, 16 ATMOS. CHEM. PHYS. 3761 (Mar. 22, 2016), https://www.atmos-chem-phys net/16/3761/2016/acp-16-3761-2016.pdf; Hansen 2016 Declaration, *supra* note 15, at ¶ 22.

[790] Abatzoglou, *supra* note 125, at 11, 15–22.

[791] Hansen, *supra* note 126, at 166 ("Also our best current estimate for the planet's mean energy imbalance over the past decade, thus averaged over the solar cycle, is about +0.5 watt per square meter. Reducing carbon dioxide to 350 ppm would increase emission to space 0.5 watt per square meter, restoring the planet's energy balance, to first approximation."). Since 2009, the energy imbalance has increased. *See* Hansen 2016 Declaration, *supra* note 15, at ¶¶ 31, 64 ("Earth's energy imbalance now averages about 0.6 Watts/m^2 . . . averaged over the entire planet. . . . The measured energy imbalance indicates that atmospheric CO2 must be reduced to a level below 350 ppm and the long-term average global temperature increase above pre-industrial levels must be limited to below 1 degree Celsius.").

[792] Intergovernmental Panel on Climate Change ("IPCC"), *Summary for Policymakers, Climate Change 2013: The Physical Science Basis: Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* 37 (2013), http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WGIAR5_SPM_brochure_en.pdf ("[T]he global average net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] W/m^2.").

[793] Hansen 2016 Declaration, *supra* note 15, at ¶ 31

[794] *Id* at ¶¶ 64, 68; Hansen, *supra* note 126, at 166; *see* Hansen, *supra* note 133, at 217–31 (detailing levels necessary to correct energy imbalance in 2009, which levels have since increased with continued GHG emissions and worsening climate changes).

[795] Hansen, *supra* note 126, at 217 ("If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, Paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm."); *see generally*, Hansen 2016 Declaration, *supra* note 15; Hansen, *Young People's Burden*, *supra* note 109.

[796] Hansen 2016 Declaration, *supra* note 15, at ¶¶ 12, 64, 68, 86, passim.

[797] *Id*.; Hansen, *supra* note 126.

[798] Hansen 2016 Declaration, *supra* note 15, at ¶¶ 20, 35; NASA, *Facts, Carbon Dioxide*, http://climate.nasa.gov/vital-signs/carbon-dioxide.

considered a safe target for present or future generations, and is not supported by current science of climate stabilization.[799] Earth's paleoclimate history demonstrates that climate impacts accompanying global warming of 2°C or more would be irreversible and catastrophic for humanity.[800] For example, the paleoclimate record shows that warming consistent with CO_2 concentrations as low as 450 ppm may have been enough to melt almost all of Antarctica.[801] The warming of the past few decades has brought global temperature close to if not slightly above the prior maximum of the Holocene epoch – "the period of relatively stable climate over the last 10,000 years that has enabled human civilization to develop."[802] Human society must keep global temperature at a level within or close to the Holocene range to prevent dangerous climate change. Global warming of 2°C would be well above Holocene levels and far into the dangerous range and has been described as "an unacceptably high risk of global catastrophe."[803]

The widely-used models that allow for 2°C temperature increase, and therefore advocate for a global CO_2 emission reduction target aimed at a 450 ppm CO_2 standard, do not take into account significant factors that will compound climate impacts. Most importantly, they do not include the slow feedbacks that will be triggered by a temperature increase of 2°C.[804] Slow feedbacks include the melting of ice sheets and the release of potent greenhouse gases, particularly methane, from the thawing of the tundra.[805] These feedbacks might show little change in the short-term, but can hit a point of no return, even at a 2°C temperature increase, that will trigger further warming and sudden catastrophic impacts. For example, the Greenland and Antarctic ice sheets "required millennia to grow to their present sizes. If ice sheet disintegration reaches a point such that the dynamics and momentum of the process take over, reducing greenhouse gases may be futile to prevent major ice sheet mass loss, sea level rise of many meters, and worldwide loss of coastal cities—a consequence that is irreversible for practical purposes."[806]

These slow feedbacks are a part of the inertia of the climate system, where "[t]he inertia causes climate to appear to respond slowly to this human-made forcing, but further long-lasting responses can be locked in."[807] Thermal inertia is primarily a result of the global ocean, which stores 90% of the energy surplus, and therefore perpetuates increased global temperature even after climate forcings, or emissions, have declined.[808] Thus, the longer we wait to reduce global CO_2 concentrations, the more thermal inertia will already be in play and the more climate impacts will continue to escalate. Alaska will play an important role in these climate forcings. Thawing permafrost throughout Alaska may be changing the state from shifting from a net sink, or storehouse, of carbon to a net source.[809]

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[799] Hansen, *Ice Melt, Sea Level Rise and Superstorms supra* note 14.
[800] *Id*.
[801] Hansen 2016 Declaration, *supra* note 15, at ¶ 35.
[802] *Id.* at ¶¶ 16, 29.
[803] *Id.* at ¶ 44.
[804] Hansen, *Assessing "Dangerous Climate Change"*, *supra* note 6, at 15.
[805] *Id*.
[806] *Id.* at 13.
[807] *Id.* at 1.
[808] *Id.* at 4–5, 13.
[809] Róisín Commane et. al. *Carbon Dioxide Sources from Alaska Driven by Increasing Early Winter Respiration from Arctic Tundra*, 114 PROCEEDINGS NAT'L ACAD. SCI. 5361 (MAY 23, 2017),

Furthermore, 2°C targets would lead to an increase in the use of fossil fuels that are more difficult to extract, and thus are compounded with the expenditure of greenhouse gases due to the transport and intensive mining process resulting in "more CO_2 [emissions] per unit useable energy."[810] The 2°C target also reduces the likelihood that the biosphere will be able to sequester CO_2 due to carbon cycle feedbacks and shifting climate zones.[811] Under the allowable emissions with the 2°C target, other greenhouse gases, such as methane and nitrous oxide would continue to increase, further exacerbating climate change impacts.[812] These factors are missing from the 2°C scenarios, which have (unfortunately) been widely accepted and used in the creation of climate policies and plans.

A temperature rise of 2°C will not only lock in a further temperature increase due to thermal inertia, but it will also trigger irreversible impacts, including rapid, nonlinear sea level rise and species loss described above.[813] Most models look at sea level rise as a gradual linear response to melting ice sheets. However, "it has been argued that continued business-as-usual CO_2 emissions are likely to spur a nonlinear response with multi-meter sea level rise this century."[814] This sea level rise would occur at a pace that would not allow human communities or ecosystems to respond.

An emission reduction target aimed at 2°C would "yield a larger eventual warming because of slow feedbacks, probably at least 3°C."[815] Once a temperature increase of 2°C is reached, there will already be "additional climate change "in the pipeline" even without further change of atmospheric composition."[816] Dr. James Hansen warns that "distinctions between pathways aimed at 1°C and 2°C warming are much greater and more fundamental than the numbers 1°C and 2°C themselves might suggest. These fundamental distinctions make scenarios with 2°C or more global warming far more dangerous; so dangerous, we [James Hansen et al.] suggest, that aiming for the 2°C pathway would be foolhardy."[817] The 2°C target is at best the equivalent of "flip[ping] a coin in the hopes that future generations are not left with few choices beyond mere survival. This is not risk management, it is recklessness and we must do better."[818] Thus, a global average atmospheric concentration of CO_2 of 450 ppm, or a concentration of CO_2e between 450 and 550 ppm, would result in dangerous anthropogenic interference with the climate system and would threaten all public natural resources in Alaska and the health and well-being of Alaskans.

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http://www.people fas harvard.edu/~rcommane/publications-/29-pnas-2017-adv_onlinesi.pdf; Henry Fountain, *Tundra May Be Shifting Alaska to Put Out More Carbon Than It Stores, Study Says*, New York Times (May 8, 2017), https://www nytimes.com/2017/05/08/climate/alaska-carbon-dioxide-co2-tundra html.

[810] Hansen, *Assessing "Dangerous Climate Change"*, *supra* note 6, at 15.

[811] *Id.* at 15, 20.

[812] *Id.* at 20.

[813] *Id.* at 6.

[814] *Id.*

[815] *Id.* at 15.

[816] *Id.* at 19.

[817] *Id.* at 15.

[818] Matt Vespa, *Why 350? Climate Policy Must Aim to Stabilize Greenhouse Gases at the Level Necessary to Minimize the Risk of Catastrophic Outcomes*, 36 ECOLOGY L. CURRENTS 185, 186 (2009), http://www.biologicaldiversity.org/publications/papers/Why_350.pdf.

Importantly, the Intergovernmental Panel on Climate Change ("IPCC") has not established nor endorsed a target of 2°C warming above the preindustrial period as a limit below which the climate system will be stable.[819] The 2°C figure was reached as a compromise between the emission reduction scenarios and associated risks summarized by Working Group I of the 2007 IPCC Fourth Assessment Report,[820] and because policy makers felt that it was politically achievable.[821] As the IPCC makes clear, "each major IPCC assessment has examined the impacts of [a] multiplicity of temperature changes but has left [it to the] political processes to make decisions on which thresholds may be appropriate."[822] Two degrees Celsius warming above pre-industrial levels has never been universally considered "safe" from either a political or scientific point of view. As the United Nations Framework Convention on Climate Change ("UNFCCC") stated: "The 'guardrail' concept, in which up to 2°C of warming is considered safe, is inadequate and would therefore be better seen as an upper limit, a defense line that needs to be stringently defended, while less warming would be preferable."[823] And according to a Coordinating Lead Author of the IPCC's 5th Assessment Report, the 2°C "danger level" seemed:

> [U]tterly inadequate given the already observed impacts on ecosystems, food, livelihoods, and sustainable development, and the progressively higher risks and lower adaptation potential with rising temperatures, combined with disproportionate vulnerability.[824]

The most recent IPCC synthesis of climate science confirms that additional warming of 1°C (we have already have 1.1°C warming above the preindustrial average)[825] jeopardizes unique and threatened systems, including ecosystems and cultures.[826] The IPCC also warns of risks of extreme events, such as heat waves, extreme precipitation, and coastal flooding, and "irreversible regime shifts" with additional warming.[827] See Figure 5 below.

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[819] *See* Hansen 2016 Declaration, *supra* note 15, at ¶ 73.
[820] *See* IPCC, *supra* note 792, at Table SPM.3.
[821] *See* Declaration of Dr. Richard H. Gammon In Support of *Foster v. Wash. Dept. of Ecology*, No. 14-2-25295-1, at 2 (Wash. King Cty. Super. Ct. Aug. 24, 2105), https://static1.squarespace.com/static/571d109b04426270152febe0/t/59a0e28f893fc051190b10a2/1503715984440/15.08.25+GammonDecl.pdf.
[822] IPCC, *Climate Change 2014: Mitigation of Climate Change, Contribution of Working Group III to the Fifth Assessment Report*, 125 (2014), http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter1.pdf.
[823] UNFCCC, 2015: *Report on the Structured Expert Dialogue on the 2013–2015 Review*, 18, https://unfccc.int/resource/docs/2015/sb/eng/inf01.pdf.
[824] Petra Tschakert, *1.5 °C or 2 °C: A Conduit's View from the Science-Policy Interface at COP20 in Lima, Peru*, CLIMATE CHANGE RESPONSES 8 (Mar. 27, 2015), http://www.climatechangeresponses.com/content/2/1/3.
[825] NASA, *Facts: Evidence: Climate Change: How Do We Know?: Global Temperature Rise*, https://climate.nasa.gov/evidence.
[826] IPCC, *supra* note 792, at 12–14.
[827] *Id.*

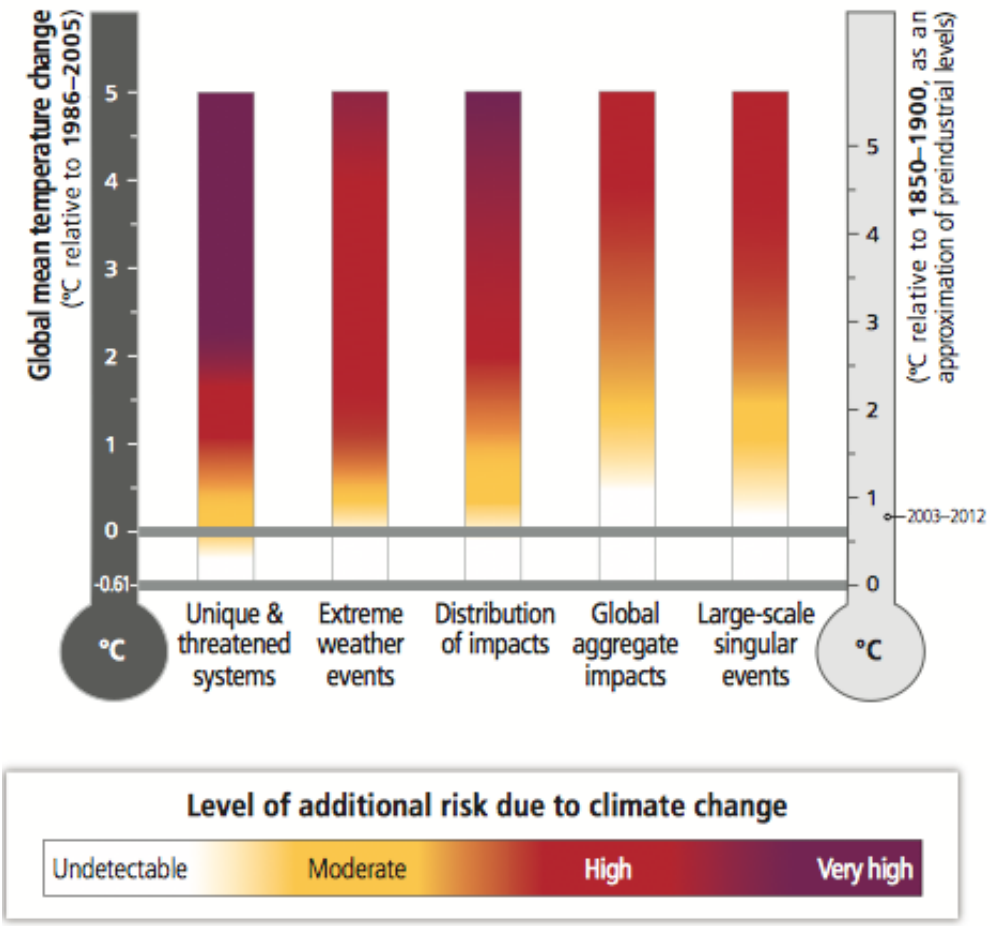

Figure 5: Burning Embers. Illustration of climate risks associated with the IPCC's principally identified reasons for concern.[828]

Oceans have the same scientific standard of protection. Alaska organisms and ecosystems are already harmed and will increasingly continue to be harmed by the effects of ocean acidification. Critically important ocean ecosystems, including fisheries, are severely threatened by present day CO_2 concentrations of approximately 400 ppm and it is vitally important that atmospheric CO_2 levels are reduced to below 350 ppm in order to protect ocean ecosystems.[829] The IPCC never concluded that 2°C warming would be safe for ocean life.[830] According to Dr. Ove Hoegh-Guldberg, one of the world's leading experts on ocean acidification and the Coordinating Lead Author of the oceans chapter of the 5th Assessment Report of the IPCC:

[828] *Id.* at 13.
[829] *See* Declaration of Ove Hoegh-Guldberg In Support of *Foster v. Wash. Dep't of Ecology*, No. 14-2-25295-1 SEA, (Wash. King Cty. Super. Ct. Aug. 24, 2015), https://static1.squarespace.com/static/571d109b04426270152febe0/t/59a0e23dd482e9c868986767/1503715905156/15.08.25+Hoegh-GuldbergDecl.pdf.
[830] IPCC, *supra* note 792, at 2.

> Allowing a temperature rise of up to 2°C would seriously jeopardize ocean life, and the income and livelihoods of those who depend on healthy marine ecosystems. Indeed, the best science available suggests that coral dominated reefs will completely disappear if carbon dioxide concentrations exceed much more than today's concentrations. Failing to restrict further increases in atmospheric carbon dioxide will eliminate coral reefs as we know them and will deny future generations of children from enjoying these wonderful ecosystems.[831]

Even the 2015 Paris Agreement backed off 2°C as a safe level of warming (though it did not go far enough to note that 1°C was the maximum safe level of long-term warming).[832] To prevent further degradation or the eventual depletion of the oceanic resources, it is imperative that atmospheric CO_2 concentrations be returned to below 350 ppm by the end of this century.

It is imperative that Alaska set GHG emission limits targeted at 1°C temperature change, or a maximum of 350 ppm in global CO_2 levels, in order for Alaska to do its part to avoid the cascading impacts that will occur with a 2°C or 450 ppm target. To reduce global atmospheric CO_2 to 350 ppm by the end of this century, this target would require that if global CO_2 emissions had peaked in 2012, they be reduced by 6% per year beginning in 2013, alongside 100 GtC of global reforestation throughout the century.[833] If emissions peaked and reductions began in 2005, only a 3.5% per year reduction would have been necessary to reach 350 ppm by 2100. If adequate emissions reduction implementation begins this year, emissions this year need to be reduced by 8.5% per year.[834] However, if emission reductions do not begin until 2020, a 15% per year reduction rate will be required to reach 350 ppm by 2100.[835] If reductions are delayed beyond 2020, it might not be possible to return to 350 ppm until well after 2500.[836]

Continued delay makes it harder and harder for Petitioners and future generations to protect a livable world. It is imperative that the Department calibrates State emission limits to put Alaska on a trajectory aimed for 350 ppm and then establish a plan that will put Alaska on a track towards ensuring that Alaska does its part to meet these limits.

Previous projections based on maintaining atmospheric carbon concentrations at or below 450 ppm are not sufficient to avoid severe, irreversible damage as a result of ocean acidification and ocean warming. According to current science, 450 ppm represents a tipping point for coral reefs worldwide. If atmospheric CO_2 levels reach this tipping point, coral reefs as we know them will be extremely rare, if not extinct, and at least half of coral-associated wildlife will become

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[831] *Id.*
[832] Paris Agreement, Article 2, Section 1(a), http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf
[833] Hansen, *Assessing "Dangerous Climate Change"*, *supra* note 6, at 10.
[834] Hansen 2016 Declaration, *supra* note 15, at ¶ 68.
[835] Hansen, *Assessing "Dangerous Climate Change"*, *supra* note 6, at 10.
[836] *Id.*; While alternative combinations of emissions reductions and sequestration rates may be utilized to achieve a reduction of atmospheric CO_2 to 350 ppm by 2100, the rates proposed by Petitioners represent the most feasible and cost-effective combination, *see* Hansen, *Young People's Burden*, *supra* note 109.

rare or extinct. As a result, coral reef ecosystems will likely be reduced to crumbling frameworks with few calcareous corals remaining.[837]

Atmospheric CO_2 levels are currently on a path to reach a climatic tipping point.[838] Absent immediate action to reduce CO_2 emissions, atmospheric CO_2 may reach levels so high that life on Earth as we know it is unsustainable at these levels.

Fossil fuel emissions must decrease rapidly if atmospheric CO_2 is to be returned to a safe level in this century.[839] Improved forestry and agricultural practices can provide a net drawdown of atmospheric CO_2, primarily via reforestation of degraded lands, returning us to 350 ppm somewhat sooner.[840] However, the potential of these measures is limited. Immediate and substantial reductions in CO_2 emissions are required in order to ensure that the Petitioners and future generations are to inherit a planet that is habitable.

A zero-CO_2 U.S. energy system can be achieved within the next thirty to fifty years without acquiring carbon credits from other countries. In other words, actual physical emissions of CO_2 from fossil fuels can be eliminated with technologies that are now available or reasonably foreseeable. This can be done at reasonable cost by eliminating fossil fuel subsidies and creating annual and long-term CO_2 reduction targets. Net U.S. oil imports can be eliminated in about 25 years, possibly less. The result will also include large ancillary health benefits from the significant reduction of most regional and local air pollution, such as high ozone and particulate levels in cities, which is mainly due to fossil fuel combustion.[841]

Experts state that approaches to transition to a renewable energy system and to phase out fossil fuels by about 2050 include: A cap on fossil fuel use that declines to zero by 2050 or a gradually rising carbon tax with revenues used to promote a zero-CO_2 emissions energy system and to mitigate adverse income-distribution effects; increasingly stringent efficiency standards; elimination of direct and indirect subsidies and other incentives for fossil fuel extraction, transportation, and combustion; investment in a vigorous and diverse research, development and demonstration program; banning new coal-fired power plants and phasing out existing coal-fired power plants; adoption of a policy that would aim to have essentially carbon-free state and local governments, including almost all of their buildings and vehicles by 2030; and adoption of a gradually increasing renewable portfolio standard for electricity until it reaches 100% by about 2050.[842] Products and services already exist for building or remodeling buildings to have zero GHG emissions; for generating sufficient electricity with zero carbon dioxide emissions; for

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[837] *See generally* J.E.N. Veron et al., *The Coral Reef Crisis: The Critical Importance of <350 ppm CO_2*, 58 MARINE POINT BULLETIN 1428 (Oct. 2009), http://www.sciencedirect.com/science/article/pii/S0025326X09003816.
[838] Hansen, *supra* note 126, at 224–30, 260.
[839] Hansen, *Where Should Humanity Aim?*, *supra* note 133, at 217 (discussing the need to reduce the atmospheric CO_2 concentration to 350 ppm).
[840] *Id*. at 227.
[841] ARJUN MAKHIJANI, CARBON-FREE, NUCLEAR-FREE: A ROADMAP FOR U.S. ENERGY POLICY (2007); Declaration of Arjun Makhijani in Support of *Alec L. v. Jackson*, https://static1.squarespace.com/static/571d109b04426270152febe0/t/59a0e358cf81e0853497b1a4/1503716186276/Makhijani+Declaration.11.09.26.pdf.
[842] ARJUN MAKHIJANI, CARBON-FREE, NUCLEAR-FREE: A ROADMAP FOR U.S. ENERGY POLICY, 15 SCIENCE FOR DEMOCRATIC ACTION 1 (AUGUST 2007), http://www helencaldicott.com/roadmap_summary.pdf.

zero-emission transportation and industrial processes; and agricultural and forest processes that can also decrease GHG emissions and increase CO_2 sequestration. The Department should fully consider these measures in achieving its own annual emissions reduction measures to transition off of fossil fuels.

Furthermore, experts have already prepared plans for Alaska (as well as every other state and over 100 countries) that would allow Alaska to transition off fossil fuels. This plan outlines how Alaska can produce 100% of its energy, for all energy sectors, from clean and renewable energy sources: wind, water, and sunlight by 2050.[843] Alaska's plan would have the state getting about 70% of its energy from onshore and offshore wind, 15% hydroelectric, 7% geothermal, about 6% from photovoltaic cells (solar), 1% tidal, and 1% wave.[844] If implemented, the plan would save Alaskans money, create jobs, and reduce mortalities. Specifically, by 2050, the cost savings would be $27,060[845] per person, per year; nearly 30,000 long-term jobs would be created; .9 billion dollars in health care costs, and 84 deaths, would be avoided every year. [846] This plan is economically and technologically feasibly, and provides a readily available plan that Alaska could implement, or use as a model.

VII. DESPITE HAVING THE RESOURCES AND STRUCTURE IN PLACE, ALASKA HAS FAILED TO ADDRESS ITS EQUITABLE SHARE OF THE CLIMATE CRISIS AND HAS INSTEAD EXECERBATED THE CRISIS

The Department has the present ability, and the clear legal duty, to curtail the environmental harms detailed above. Atmospheric CO_2 concentrations will decrease if states stop (or greatly reduce) their burning of fossil fuels.[847] The environmental harms and threats to human health and safety as described above can only be avoided if atmospheric CO_2 concentrations are immediately reduced. Any more delay risks irreversible and catastrophic consequences for youth and future generations. Petitioners, other Alaska youth, and future generations have a right to be free from government action which infringes their constitutional and Public Trust rights. Alaska, including the ADEC, infringes these rights so long as it persists in actions which cause and exacerbate the current climate crisis through the permitting, authorization, and incentivizing of the development, extraction, combustion, and transportation of fossil fuels and other emissions generating activities, and so long as the state and ADEC fail to take action to do their share to address the climate crisis. These infringements can only be rectified by the adoption of a state-mandated, science-based, emissions reduction strategy. ADEC's continuing actions and

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[843] Jacobson, *supra* note 787; *see also* Travis Madsen & Rob Sargent, *We Have the Power: 100% Renewable Energy for a Clean Thriving America*, Environment America Research & Policy Center (2016), available at http://www.environmentamerica.org/sites/environment/files/reports/We%20Have%20the%20Power-%20100%20Percent%20Renewable%20Energy%20for%20a%20Clean%20Thriving%20America%20-Environment%20America.pdf.

[844] Jacobson, *supra* note 787, at 2099; The Solutions Project, *100% Alaska*, http://thesolutionsproject.org/infographic/img/infographics/100_Alaska.pdf.

[845] The cost savings include electricity cost savings, air quality damage savings, and climate costs savings to the world.

[846] Jacobson, *supra* note 787, at 2106, 2108, 2111.

[847] HARVEY BLATT, AMERICA'S ENVIRONMENTAL REPORT CARD, xiii (2005) ("How can we stop this change in our climate? The answer is clear. Stop burning coal and oil, the sources of nearly all the carbon dioxide increase."), http://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=3129&context=jssw.

omissions in this respect contradict the Department's own position on its duty to address the climate crisis.

ADEC has publicly affirmed its authority and obligation to meaningfully address climate change. In a presentation before the legislatively-appointed *Alaska Climate Impact Assessment Commission* (ACIAC), the Department concluded that "**[i]t's a DEC duty not only to react / mitigate, but to act to prevent and to control damage to the environment caused by greenhouse gases**."[848] ADEC cited its statutory mandate and codified state policy as the basis for its stated duty.[849] ADEC's recognition of its authority and obligation in this regard finds clear support in numerous sources of Alaskan law; the Department's power and duty to promulgate a rule limiting Alaska's GHG emissions is rooted in the Alaska Constitution, the Public Trust Doctrine and multiple Alaska Statutes

During a 2007 public presentation before the legislatively-established Alaska Climate Impacts and Assessment Committee, ADEC unequivocally declared not only its *authority* to create a rule mitigating against climate change, but also its *duty* to so do: "**It's a DEC duty not only to react / mitigate, but to act to prevent and to control damage to the environment caused by greenhouse gases**."[850] In 2008, the legislatively created Alaska Climate Impact Assessment concluded in its report to the legislature that Alaska needs "adaptable legal and policy frameworks" to help account for the inevitable "new responsibilities for the State of Alaska and public entities" with respect to climate change.[851] New state-level rules and responsibilities are needed, and ADEC is the department that can and, by its own admission, *must* adopt new rules and outline new responsibilities.

Government-requested, Alaska-specific, climate change assessments have been conducted for over 15 years – all of which indicate that State GHG emissions must be reduced to mitigate against climate change – and ADEC, the state administrative agency tasked with promulgation of regulations for the protection and conservation of the environment and human health and welfare, long-ago went on record as having the authority and owing the duty to regulate Alaska's GHG emissions. Still, Alaska does not have so much as a climate action plan. No more assessment is needed before action can begin. ADEC has the authority, wherewithal, support, and—most importantly—*duty* to protect Alaskans from further suffering and devastation caused by climate change. ADEC can and should adopt the proposed emissions reduction rule.

A. *U.S. Senate Special Hearing on Climate Change, Fairbanks, 2001*

Assessing local climate change impacts is nothing new to Alaskans. Over fifteen years ago, in his capacity as Chairman of the Committee on Appropriations, Republican U.S. Senator for Alaska Ted Stevens chaired a Special Hearing before the Committee. The hearing, held in

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[848] *See ADEC Presentation*, *supra* note 5, at 66 (emphasis in original).
[849] *Id.*
[850] *See ADEC Presentation*, *supra* note 5, at 66.
[851] *Final Commission Report to the Alaska State Legislature*, ALASKA CLIMATE IMPACT ASSESSMENT COMMISSION ["ACIAC"] 3 (Mar. 17, 2008), http://climatechange.alaska.gov/aag/docs/O97F17502.pdf [hereinafter ACIAC Final Report].

Fairbanks, "assembled a very distinguished group of scientists and government officials to present [the Committee] facts and predictions on the Arctic climate change issue and the impact it is having on the Arctic Region."[852]

Senator Stevens, once a climate change skeptic, opened the hearing by noting that "what is happening [in Alaska] will have a significant impact on the Nation…as well as the world, perhaps."[853] Stevens went on to state his belief that "practical responses to address the impact of climate change" were needed—and needed soon. Citing the fact that Alaska Native villages were "losing land because of the increased inundation of the sea," Stevens called "the encroachment of the ocean on the small villages" a "slow-moving disaster that may require more than a slow-moving response as far as the Federal and State governments are concerned."[854]

Many local experts took part in the Hearing, including: Dr. Akasofu and Orson Smith of the University of Alaska; Caleb Pungowiyi, "an Alaskan Native who has observed the impact of climate change along the coastline of Alaska;" and George Newton of the Arctic Research Commission.[855] The experts who presented at the Special Hearing did their part to outline the impending climate crisis. For example, Dr. Margaret Leinen, on behalf of the U.S. Global Change Research Program (which is "the U.S. interagency program charged by Congress to coordinate the national research effort on global change" ("USGCRP")), convincingly presented on the science and effects of climate change impacts already being felt in Alaska.[856] Dr. Leinen's presentation drew heavily from a 1999 regional report on Alaska. The report, titled "Preparing for a Changing Climate" and sponsored by DOI/USGS, NSF, NOAA and the International Arctic Science Committee, detailed Alaska impacts such as: "permafrost thawing and sea-ice melting, increased risk of fire and insect damage to forests, sensitivity of fisheries and marine ecosystems, and increased stresses on subsistence livelihoods."[857]

Senator Stevens held the Special Hearing because he was "*especially interested in establishing a record of what is happening in the arctic region of [Alaska]*."[858] He wanted these impacts known; known to his fellow Appropriations Committee members and his fellow Alaskans alike. Moreover, by calling the Special Hearing, and then choosing to hold it not in Washington D.C. but in Fairbanks, Senator Stevens hoped to not just introduce the world to this "slow-moving disaster,"[859] but also to spur swift governmental action in Alaska to stop it.[860] Unfortunately, bringing a prominent Senate Committee and a slew of scientific experts to

[852] *See* Hearing before the Senate Committee on Appropriations, *supra* note 746, at 2.
[853] *Id.*
[854] *Id.* (emphasis added).
[855] *Id.* at 2.
[856] *Id.* at 51–55.
[857] *Id.* at 53; *see also* Alaska Regional Assessment Group, *Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change, Alaska*, CENTER FOR GLOBAL CHANGE AND ARCTIC SYSTEM RESEARCH, UNIVERSITY OF FAIRBANKS, ALASKA (Dec. 1999), http://www.besis.uaf.edu/regional-report/regional-report html.
[858] Hearing before the Senate Committee on Appropriations, *supra* note 746, at 2.
[859] *Id*.
[860] *Id*.

Fairbanks to publicly discuss climate change and its impacts on Alaska did not spur state-level GHG reduction action.

While Alaskans have seen climate change impacts worsen in the subsequent sixteen years, no effort has been made to regulate GHG emissions in the wake of the 2001 Special Hearing. Efforts have instead gone into "further assessment."

B. *State Legislature Creates ACIAC, State Assessment Begins, 2006*

The Alaska State Legislature created the *Alaska Climate Impact Assessment Commission* (ACIAC) on June 7, 2006, with the passage of HRC 30.[861] ACIAC's purpose was "to develop a comprehensive, preventative assessment and adaptation plan to address the issues that will help save lives, protect public health, preserve economic and resource development, and protect valuable infrastructure.[862] ACIAC was to, among other things, "recommend **policies to decrease the negative effects of climate change**," and asked to "**identify and coordinate efforts of mutual concern with federal, state, and local agencies**."[863]

As a part of its policy assessment, ACIAC held six public hearings across Alaska.[864] These hearing provided local residents the opportunity to educate the Commission on how climate change impacts were already affecting Alaskan lives. The hearings also allowed public and private climate professionals and experts a chance to inform ACIAC of future impacts and ways to maximize the state's resources to mitigate against climate change. State residents and agencies were given a voice, an opportunity to step up and ask for—or offer—help.[865] In 2007, ADEC did just that: ADEC presented on the need for help while also articulating the duty it owes to Alaskans and preparations it had already made for promulgating an emissions reduction rule.[866]

C. *ADEC's Presentation: A Warning, the Department's Duty and Authority to Act, and an Economically Viable Transition Plan*

Mitigating climate change requires leadership – leadership that ADEC has publicly affirmed that it is authorized, obligated, and able to provide. As ADEC has recognized for over ten years, the Department is duty-bound to protect Alaskans from a changed, unbalanced atmosphere. Not only is a state-wide transition to renewable energy possible, as the Department has acknowledged, it is economically viable. Over ten years ago, the Department recognized each of these points, highlighting its appropriate role as the leader in climate change regulation in the State of Alaska.

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[861] State of Alaska Legislature HRC 30, Legislative Resolve 49, http://www.legis.state.ak.us/PDF/24/Bills/HCR030Z.PDF [hereinafter HRC 30].
[862] HRC 30 *Fact Sheet* 2, https://www.c2es.org/docUploads/AK-FactSheetonC%20C%20%20(2)%20(2).doc.
[863] *ADEC Presentation*, *supra* note 5, at 6, (emphasis in original); HRC 30, *supra* note 861, at 4.
[864] ACIAC Final Report, *supra* note 851, at 1.
[865] *Id*. at 2.
[866] *See ADEC Presentation*, *supra* note 5.

1. ADEC Warned Alaska Politicians of Climate Change Impacts Over Ten Years Ago

On January 24, 2007 ADEC presented before ACIAC.[867] Beginning with a slide stating that "[a]rctic climate is now warming rapidly and much larger changes are projected," ADEC publicly outlined for ACIAC some of the many expected climate change impacts on Alaska [868] – impacts we now know would indeed come to bear (see, Section VI). ADEC's summarized discussion of climate change impacts in Alaska included:

- Widespread melting of glaciers and sea ice, and a shortening of the snow season;
- Increasing precipitation, shorter and warmer winters, and substantial decreases in snow cover and ice cover;
- Increasing exposure of coastal communities to storms;
- Thawing permafrost and associated weakening of coastal lands;
- Increased risk of flooding;
- Increased risks and costs and forced relocation of communities in coastal zones;
- Thawing ground will disrupt transportation, buildings, and other infrastructure;
- Threats and increased costs to sanitation infrastructure;
- Reduction in supply and contamination of water sources;
- Structural damage to piped water and sewer infrastructure;
- Impacts to waterways and aquatic wildlife, including salmon;
- Impacts to and associated with wastewater and solid waste treatment and disposal;
- Air quality impacts;
- Different diseases in foods: seafood, animals and produce;
- More frequent oil spills in rural coastal and river communities due to storms and flooding – investment and response challenge;
- Relocation, modification with re-investment for existing water and sanitation systems; changes in design for new systems;
- Changing strategies/practices for preserving fish habitat through water quality / land management;
- Fire smoke pollution must be actively managed for health protection; integrated with firefighting agencies;
- Others impacts that are currently less obvious[869]

2. ADEC to ACIAC: ADEC has a Duty to Prevent GHG-caused Damage

ADEC also presented on its duty to prevent further GHG-caused damage: The Department publicly presented on its "**duty not only to react / mitigate, but to act to prevent and to control damage to the environment caused by greenhouse gases**."[870] Further, the Department

[867] ACIAC Final Report, *supra* note 851, at 1.
[868] *See id*. at 39–54, 59, 61–65.
[869] *Id*.
[870] *Id*. at 66 (emphasis in original) (as the basis for this duty, ADEC cites both Alaska Stat. §§ 44.46.020(3) ("promote and develop programs for the protection and control of the environment of the state").

affirmed its authority and ability to serve as the leader of climate change regulation in Alaska, stating: "DEC can lead the regulatory functions of reducing emissions."[871] Adopting the proposed rule would allow ADEC to meet its duty to lead in addressing climate change in Alaska.

3. ADEC to ACIAC: Climate Change Regulation is Economically Viable

Notably, ADEC presented on the economic viability of GHG regulation.[872] While speculating on the legal and economic effects of GHG regulation in Alaska, ADEC concluded that:

- Free market principles will be used to achieve flexibility for lowest cost solutions – worked for acid rain;
- Carbon dioxide and other GHGs will be a commodity traded and regulated by markets and governments;
- Free market principles will create new economic opportunities as well the expected carbon (fuel) user costs;
- Many accounting and regulatory rules will get defined with a drive toward uniform rules nationally and internationally;
- Low hanging fruit in fuel efficiency and energy conservation will make reductions comparatively easy for the first decade;
- Existing federal and state air pollution control / permitting framework will be the primary implementing tool.[873]

4. ADEC to ACIAC: ADEC is Prepared to Promulgate GHG Laws

Further, ADEC's presentation highlighted the state's inaction[874] while offering to spearhead state action moving forward: "[ADEC] can lead the regulatory functions of reducing emissions."[875] ADEC indicated to ACIAC that it was prepared to regulate, noting that it "has tracked action in other states," and has "participated with western states in building market and agency fundamentals: Inventory emissions of greenhouse gases, exploring a common 'Registry' format for bookkeeping and validation of reductions."[876] While ADEC is duty-bound to serve as the primary regulator and leader in reducing GHG emissions in Alaska, ADEC identified for ACIAC several state agencies already in existence, including "DCCED, DNR, Revenue, RCA, AOGCC," that would be able to help with any "life style changes, energy use, community and economic challenges."[877]

5. ACIAC's Findings and Recommendations

[871] *Id*. at 68.
[872] *Id*. at 67.
[873] *Id.*
[874] *Id*. at 69 ("state law does not currently regulate greenhouse gases").
[875] *Id*. at 68.
[876] *Id*. at 69.
[877] *Id*. at 68.

In its final report back to the Alaska Legislature, ACIAC detailed a number of alarming impacts of climate change projected for and already occurring in Alaska.[878] ACIAC further stated stated that:

> The Commission found that climate change presents unavoidable challenges to the citizens of Alaska. **There will be new responsibilities for the State of Alaska and public entities**, and there will be responsibilities for private interests which individuals must accept.[879]

With regard to Alaska's impending "new responsibilities," despite ADEC's publicly acknowledged duty to prevent and control damage to the environment associated with greenhouse gases, and its authority and ability to do so, the Department has thus far failed to adopt and implement GHG-limiting regulations.

D. *Administrative Order No. 238: Alaska Climate Change Sub-Cabinet*

On September 14, 2007, then-Governor Sarah Palin established the Alaska Climate Change Sub-Cabinet ("CCSC") by Administrative Order No. 238 ("Order No. 238").[880] CCSC, which was made up of commissioners of several state departments,[881] was enacted to advise the office of the Governor "on the preparation and implementation of an Alaska climate change strategy" and "serve as the executive branch contact to, and a resource for, the Alaska Climate Impact Assessment Commission."[882]

Order No. 238 was made based on expert findings, including that "[a]s a result of [global] warming, coastal erosion, thawing permafrost, retreating sea ice, record forest fires, and other changes are affecting, and will continue to affect, the lifestyles and livelihoods of Alaskans."[883] The order acknowledged that climate change is not just "an environmental issue," but "also a social, cultural, and economic issue important to all Alaskans."[884]

Order No. 238 was a call for action, stating that: "The purpose of the Climate Change Sub-Cabinet [wa]s to advise the Office of the Governor on the preparation and implementation of an Alaska climate change strategy."[885] Importantly, Alaska's climate change strategy "**must be built on sound science and the best available facts**,"[886] and was meant, in part, to further the

[878] ACIAC Final Report, *supra* note 851.
[879] *Id.* at 3 (emphasis added).
[880] *See* Order 238 *supra* note 353.
[881] Including Commissioners of the Departments of Environmental Conservation; Natural Resources; Fish and Game; Transportation and Public Facilities; and Commerce, Community, and Economic Development. *See id*.
[882] *Id*.
[883] *Id*.
[884] *Id*.
[885] *Id*. ("Alaska needs a strategy to identify and mitigate potential impacts of climate change and to guide its efforts in evaluating and addressing known or suspected causes of climate change.").
[886] *Id*.

possibility of adopting policies **"to regulate greenhouse gas emissions**."[887] Notably, *Governor Palin's Report on the Climate Sub-Cabinet* addresses the possibility of regulation of GHG emissions immediately after acknowledging Alaska's duty to protect: "*All life on Earth shares **one atmosphere and** each nation, **each state, bears a responsibility to all to protect it***."[888] Thus, in addition to the text of Alaska's *Constitution* and *Statutes*, and statements made by Alaska's *Department of Environmental Conservation*, Alaska's former *Executive* (Governor Palin) too has articulated Alaska's duty to protect the atmosphere and vital natural resources.

Notably, ADEC and its staff were integral to the Climate Change Sub-Cabinet's purpose and function.[889] CCSC was chaired by ADEC Commissioner Larry Hartig,[890] and ADEC staff drafted several Sub-Cabinet meeting agendas and internal documents.[891] In particular, ADEC was instrumental in CCSC's Mitigation Advisory Group ("MAG") functions: providing MAG with "specific leadership and support" and "vital assistance throughout."[892]

1. Advisory Groups' Official Recommendations

CCSC recommendations to the office of the governor were drawn from the recommendations of the Adaptation Advisory Group ("AAG"), which assessed Alaska's potential adaption strategies (i.e. the measures taken to respond to the effects of climate change), and the MAG, which assessed Alaska's mitigation options (i.e. measures that can be taken to reduce Alaska's greenhouse gas emissions, address causes of climate change).[893] MAG, the Group responsible for recommending options designed to lower Alaska's GHG emissions and address the cause(s) of climate change, was, in turn, made up of five "Technical Work Groups" ("TWGs"). Theses TWGs were "assembled around general greenhouse gas mitigation action categories," including: (1) oil and gas; (2) energy supply and land use; (3) transportation and land use; (4) forestry, agriculture and waste, and; (5) cross-cutting issues.[894]

Each of these five TWGs was asked to recommend policy options to MAG. MAG made all final decisions as to policy options that would be officially recommended up the chain to the CCSC:

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[887] *Governor Palin's Report on the Climate Change Sub-Cabinet* (July 2008), http://climatechange.alaska.gov/docs/govrpt_jul08.pdf.
[888] *Id.* (emphasis added).
[889] *See Alaska Climate Change Strategy's Mitigation Advisory Group Final Report*, at EX-2 (August 2009), available at http://climatechange.alaska.gov/mit/mag htm [hereinafter MAG Final Report] ("Alaska's Department of Environmental Conservation (DEC) provided the overall leadership of the effort and substantive support."); *see generally See Alaska Climate Change Strategy's Mitigation Advisory Group Final Report*, (August 2009), available at http://climatechange.alaska.gov/mit/mag.htm
[890] *See id.* at Appendix B: Description of Alaska Advisory Group Process, B-2, http://climatechange.alaska.gov/mit/O97F21911.pdf; *see also Climate Change in Alaska*, http://climatechange.alaska.gov/mbrs.htm.
[891] *See Climate Change Sub-Cabinet Meeting Handouts*, *available at* http://climatechange.alaska.gov/mtgs htm.
[892] MAG Final Report, *supra* note 889, at 1-6.
[893] *See id*. at B-3–B-9.
[894] *See id*. at p. B-6–B-9.

> After months of iteration, each TWG crafted a list of priority policy options, which the MAG reviewed, refined, and approved or turned back to the TWGs for further examination, clarification, and detail. The TWGs spent countless hours examining and refining the policy options as directed by the MAG. The MAG ultimately conducted multiple reviews on each policy option before approving them.[895]

The Cross-Cutting Issues TWG ("CC TWG") was responsible for making policy recommendations "that cover multiple sectors." The CC TWG made six policy recommendations:

(1) establishing an Alaska GHG emission reporting program [headed by ADEC[896]];
(2) establishing goals for statewide GHG emission reductions;
(3) identify and implement state government mitigation actions;
(4) integrate Alaska's climate change mitigation strategy with the Alaska energy plan;
(5) explore various market-based systems to manage GHG emissions;
(6) coordinate implementation of Alaska's efforts to address climate change.[897]

The prospect of federal action complicated MAG's review of the CC TWG's recommendations. For example, MAG, having been encouraged that "[r]ecent recognition of climate change at the federal level may provide national guidance to states, as well as reinforce state-level activities,"[898] wanted its recommendations to work in concert with expected federal regulations. "However, the undefined time frame for emerging federal rules" was seen by MAG as posing "challenges for Alaska and other states."[899] Ultimately, because it was "unclear when a final [EPA] rule w[ould] be approved," MAG opted to put the CC TWG-recommended policy to establish an Alaska GHG emission reporting program on hold "until the federal rule is released in its final form."[900] Nearly eight years have passed since that decision, during which time the effects of climate change, and the associated necessity of decisive state action, have only increased.

As a practical matter, CC TWG's second recommendation – proposed state-wide GHG emission reduction goals[901] – would necessitate the recommended GHG emissions reporting

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[895] *See id*. at 1-9.
[896] *Id*. at 3-3 ("Under the proposed Alaska GHG reporting program, Alaska's Department of Environmental Conservation (DEC) would collect, verify, and analyze GHG emissions data to establish a baseline of anthropogenic (human-caused) GHG emissions for Alaska, and identify the types and magnitude of anthropogenic GHG emission sources in Alaska and their relative contributions. These data would be used to inform state leaders and the public on statewide GHG emission trends, identify opportunities for reducing GHG emissions, and allow the state to assess its climate change mitigation efforts over time.").
[897] *Id*. at 3-1, Table 3-1.
[898] *Id*. at 3-2.
[899] *Id*. at 3-2.
[900] *Id*. at 3-2.
[901] *Id*. at 1-9 ("The CC TWG recommended 20% below 1990 GHG emission levels by 2020, and 80% below 1990 levels by 2050."). Tellingly, these figures were based on the "United Nations Intergovernmental Panel on Climate Change recommendation to keep atmospheric CO_2 levels at 450 parts per million or lower to avoid the major

program, a program MAG voted to put on hold. Nevertheless, by a majority vote, **MAG recommended the Sub-Cabinet adopt numeric GHG emissions reduction goals**.[902] Similarly, CCSC's Research Needs Work Group recommended "[a]daptable legal and policy frameworks," explaining that:

> Many laws, regulations and policies on the federal, state, and local levels were developed for a static environment where climate change was not recognized. The challenge for government leaders and businesses will be to adapt to a future made less certain due to a more rapidly changing climate. **This will necessitate an evaluation of existing laws, regulations and policies and possible changes to institutional, legal and policy frameworks in an adaptive manner**.[903]

The Climate Change Sub-Cabinet was tasked with assessing the impacts of climate change and making mitigation and adaptation policy recommendations to the Office of the Governor. Regulating GHG emissions was intended to be a part of this assessment, and it was. Almost a decade ago, after a complicated and thorough assessment process—which ADEC was intimately involved in—adopting GHG regulations was formally recommended before the CCSC as a mitigation option.[904] Notwithstanding the recommendations, no Alaska branch or agency of government has enacted or adopted state-wide GHG emission regulations.

2. Since ACIAC and CCSC's Final Reports

After issuing its final report to the legislature in 2008, ACIAC was not commissioned to take further action. The Alaska Legislature has since taken no alternative climate action. After taking over as Governor on July 26, 2009, former ConocoPhilips executive, Sean Parnell effectively allowed the CCSC created by Gov. Palin to wither on the vine while climate change continues, unabated, to ravage the state.[905] **The Sub-Cabinet has not convened since 2011.**

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irreversible damage to the planet's ecosystem." *Id.* at 1-9–1-10. As discussed in Section VI.C infra, the best climate science established that CO_2 must be restored to 350 ppm or less in order to avoid such irreversible damage.

[902] MAG Final Report, *supra* note 889, at 1-9, 3-1–3-7.

[903] *Research Needs Work Group: Recommendations on Research Needs Necessary to Implement an Alaska Climate Change Strategy*, 11 (June 2009) (emphasis added), http://climatechange.alaska.gov/docs/rn_12jun09_dftrpt.pdf.

[904] MAG Final Report, *supra* note 889 at EX-12, 3-1–3-7; *see id.* at 6-5–6-6. Notably, the MAG's recommendation to focus regulatory efforts on participating in development and implementation of a regulatory framework was premised on the assumption that "[t]he federal government will impose GHG regulations and requirements independent of Alaska." *Id.* However, what little proposed GHG federal regulations had been suggested (which were insufficient to address the impending climate emergency) are now being systematically deconstructed by the current United States executive administration. *See, e.g.*, Exec. Order 13783, 82 Fed. Reg. 16093 (March 28, 2017) (directing rollback of Clean Power Plan, rescinding moratorium on coal mining on federal lands, and rescinding six Obama administration executive orders aimed at curbing climate change and regulating emissions, including inclusion of climate change impacts in environmental reviews); President Donald Trump, "Statement by President Trump on the Paris Climate Accord" (June 1, 2017) (Announcing United States' withdrawal from the international Paris Climate Accord), https://www.whitehouse.gov/the-press-office/2017/06/01/statement-president-trump-paris-climate-accord. Accordingly, leadership by ADEC in regulating GHG emissions is more necessary than ever to safeguard the rights and heritage of Alaskans.

[905] *See Climate Change Sub-Cabinet Meeting Handouts*, *supra* note 891; *see also* Amanda Terkel, *Sarah Palin's Climate Change Sub-Cabinet Goes Dormant Under Alaska Governor Sean Parnell*, HUFFINGTON POST (Feb. 6,

Notwithstanding the findings and recommendations put forth by ACIAC and CCSC. Gov. Parnell sought to reopen the debate over drilling for oil and gas in the Arctic National Wildlife Refuge.[906] Governor Walker, who took over for Governor Parnell in 2014, has likewise thus far failed to take effective measures consistent with the state's duties to address the dangers and realities of climate change. Rather than ending further contribution of GHG emissions to the already over-saturated atmosphere, Governor Walker has gone as far as to propose "*extra*" oil drilling to offset Alaska's already skyrocketing climate change-related costs.[907] Governor Walked continues to advocate for expansion of oil and gas development in Alaska, and has aggressively pursued a state-owned natural gas pipeline. [908]

By taking affirmative actions that allow GHG emissions to continue at dangerous levels and by failing to take sufficient action to do its part to ensure public safety in the face of dangerous climatic changes, the state and ADEC are failing to fulfill their governmental duty to safeguard Public Trust resources, infringing Petitioners' due process rights, and discriminating against Petitioners in contravention of principles of equal protection. After spending more than a decade and millions of dollars on assessment, since ACIAC and CCSC presented on their respective findings, the State of Alaska has yet to adopt any policy aimed at addressing and alleviating the dangers climate change poses to Alaska's youth, its posterity, and the natural resources and environment on which their lives depend. Instead, Alaska and ADEC have persisted in business as usual approvals, permits, and authorizations of activities that substantial contribute to the climate crisis and infringe Petitioners' inalienable rights. Alaska and ADEC's persistent failure to reverse course and address Alaska's fair share of the climate crisis constitutes a further, continuing violation of those rights. The people of Alaska, especially its youth, including Petitioners, and future generations, cannot wait any longer for the state to take action to protect their rights. It is increasingly urgent that the Department delay no longer and immediately fulfill its obligation to promulgate a rule to reduce the state's GHG emissions according to the best climate science.

E. *Alaska Has the Resources and Structurers in Place to Act*

ADEC need not wait any longer. ADEC is uniquely situated: it has a duty to prevent further GHG-caused damage, the authority and wherewithal to promulgate a needed emissions reduction rule and the stated ability to lead the GHG regulatory functions. ADEC cannot meet its duty to act by waiting for Executive or Legislative direction. The degree of urgency is simply too

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2013), http://www huffingtonpost.com/2013/02/06/sarah-palin-climate-change_n_2630262 html; DEC Response to Public Records Request (Feb. 1, 2013), http://www.peer.org/assets/docs/ak/2_5_13_Alaska_climate_explanation.pdf (DEC admits last CCSC Group meeting was in 2011, refuses to release final MAG agendas from 2010).

[906] See Jake Miller, *Alaska Gov. Sean Parnell Seeks to Reopen Arctic National Wildlife Refuge Drilling Debate*, CBS NEWS (June 1, 2013), http://www.cbsnews.com/news/alaska-gov-sean-parnell-seeks-to-reopen-arctic-national-wildlife-refuge-drilling-debate.

[907] *See* Matt McGrath, *Alaska Mulls Extra Oil Drilling to Cope with Climate Change*, BBC (Oct. 12, 2015), http://www.bbc.com/news/science-environment-34501867.

[908] Letter from Bill Walker, AK Governor, to Donald Trump, United States President-Elect (Dec. 1, 2016), https://drive.google.com/file/d/0B8b0jv11oH0kVzdlM1dCZExpOTA/view; Letter from Bill Walker, AK Governor, to Ryan Zinke, U.S. Dep't Interior Secretary Nominee (Jan. 5, 2017), https://drive.google.com/file/d/0B8b0jv11oH0kbFVmRmNvX2QtTTg/view.

great. **This petition should be seen for what it is: an opportunity for ADEC to fulfill its constitutional, statutory, and Public Trust obligations and do what it has said needs to be done. An emissions reduction rule needs to be promulgated, and ADEC has the authority and obligation to fulfill that need.**

The legislature has tasked the Department of Environmental Conservation with the primary responsibility, authority, and obligation to adopt necessary regulations to conserve, improve, and protect State natural resources in order to enhance the health, safety, and welfare of the people of the state, and fulfill the State's public trust duty to present and future generations.[909] ADEC has affirmed that these fiduciary duties require the Department to take affirmative measures to address climate change. Citing AS §§ 46.03.010 and 44.46.020(3), ADEC has publicly stated that: "**It's a DEC duty not only to react / mitigate, but to act to prevent and to control damage to the environment caused by greenhouse gases."**[910]

The Department of Environmental Conservation is the primary delegated trustee of the state when it comes to assessing and addressing climate change. While ADEC has been the Department responsible for educating[911] and overseeing[912] state-appointed climate assessment and strategy commissions and groups, ADEC has had lots of help. ADEC has worked closely with many other public (and private) departments, agencies and groups on climate change impacts assessment and strategy. Although ADEC is the agency with primary responsibility for issuing regulations necessary to implement an effective emissions reductions strategy (see Section V *supra*), these entities may be available to assist and ensure that such a strategy is implemented efficiently and responsibly across all sectors of Alaska. Included are still-in-tact as well as dormant groups, all of which may be of assistance. Some of these groups are:

The Governor's "Alaska Climate Change Sub-Cabinet," which is made up of:

- The *Adaptation Advisory Group*, composed of the following work groups:
  - public infrastructure
  - health and culture
  - natural systems, and
  - economic activities
- *Mitigation Advisory Group*, which is made up of five work groups:
  - oil and gas
  - energy supply and demand
  - transportation and land use
  - forestry, agriculture and waste, and
  - cross-cutting issues
- *Research Needs Workgroup*

[909] *See* ALASKA STAT. §§ 46.03.010(a), (b); 46.03.020(10); 44.46.020(a). By constitutional command, the State of Alaska "shall provide for the utilization, development, and conservation of all natural resources belonging to the State, including land and waters, for the maximum benefit of its people."
[910] *See ADEC Presentation*, *supra* note 5, at 66 (emphasis in original).
[911] *See ADEC Presentation*, *supra* note 5.
[912] MAG Final Report, *supra* note 889, at EX-2 ("Alaska's Department of Environmental Conservation (DEC) provided the overall leadership of the [Mitigation Advisory Group] effort and substantive support.").

- *Immediate Action Group*,[913] the members of which include:
  - *United States Army Corps of Engineers*
  - *Department of Commerce, Community and Economic Development*
  - *Department of Natural Resources, Division of Forestry*
  - *Department of Transportation and Public Facilities*
  - *Denali Commission*
  - *Alaska Municipal League*
  - *Alaska State Legislative Budget & Audit Committee*
  - *Alaska Division of Homeland Security / Emergency Management*
  - *National Oceanic and Atmospheric Administration*
  - *Alaska Native Tribal Health Consortium*
  - *Environmental Protection Agency*
  - *US Economic Development Administration - Department of Commerce; AK Office*[914]
- The "Climate, Ecosystems & Human Health Work Group" (formerly known as the "Alaska Interagency Ecosystem Health Work Group"), which is Co-chaired by:
  - the *Alaska Dep't of Health and Social Services* - Division of Public Health,
  - the *US Environmental Protection Agency*, and
  - the *Alaska Native Tribal Health Consortium* - Center for Climate and Health, and directly partners with:
    - The Centers for Disease Control (CDC),
    - Alaska Pacific University (APU),
    - UAA's Institute for Circumpolar Health Studies,
    - Alaska SeaLife Center,
    - US Arctic Research Commission,
    - US Geological Survey (USGS),
    - US Fish & Wildlife Service (USFWS),
    - Alaska Dep't of Environmental Conservation (ADEC),
    - Alaska Wildlife Conservation Center,
    - UAF's Alaska Center for Climate Assessment & Policy (ACCAP)[915];
- Alaska Climate Change Impact Mitigation Program[916]
- Alaska Native Tribal Health Consortium, [917] which has partnered on climate change issues with
  - *Center for Climate and Health*
  - *Department of Environmental Health and Engineering*

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[913] *See Climate Change Advisory Groups Background*, CLIMATE CHANGE IN ALASKA, http://climatechange.alaska.gov/advgrp.htm.
[914] *See Immediate Action Workgroup*, CLIMATE CHANGE IN ALASKA, http://climatechange.alaska.gov/iaw.htm.
[915] *See Climate, Ecosystems, and Human Health Work Group*, CLIMATE CHANGE IN ALASKA, http://climatechange.alaska.gov/chh htm ("This interagency led group focuses on addressing ecosystem impacts to human health resulting from a changing climate.").
[916] *See Alaska Climate Change Impact Mitigation Program*, CLIMATE CHANGE IN ALASKA (Feb. 2011), http://climatechange.alaska.gov/docs/afe11/ACCIMP_cox_feb11.pdf ("Established by Alaska Legislature in 2008 to assist communities imminently threatened by climate change phenomena.").
[917] *See* Mike Black, *Climate Change Impacts in Alaska*, ALASKA NATIVE TRIBAL HEALTH CONSORTIUM (Feb. 2011), http://climatechange.alaska.gov/docs/afe11/CCH_black_feb11.pdf.

- Alaska Department of Transportation and Public Facilities[918]
- U.S. Army Corps of Engineers[919]
- The Department of Commerce, Community, and Economic Development; The Department of Natural Resources; the Department of Revenue, the Regulatory Commission of Alaska, and the Alaska oil and Gas Commission[920]
- National Oceanic and Atmospheric Administration
- National Marine Fisheries Service
- Alaskan Non-Governmental Organizations

As ADEC itself has publicly affirmed, it has the authority, ability, and willingness to "lead the regulatory functions of reducing emissions."[921] With ADEC at the helm and an ADEC regulation mandating GHG reductions in line with the best climate science in place, these groups, collectively, can assist ADEC in effectively addressing climate change in the State of Alaska.

VIII. CONCLUSION

As indicated above, the Alaska Department of Environmental Conservation has both the legal obligation and authority to do its part to protect the citizens of Alaska from catastrophic climate change. The best climate science indicates that a return to an atmospheric concentration of 350 ppm of CO_2 by the end of the century is needed. Therefore, Petitioners respectfully request that the Department lead Alaska's efforts to reduce carbon dioxide and other greenhouse gas emissions by promulgating the proposed rule (or a similar rule that accomplishes the intended purpose of this rule):

ADEC's adoption of the proposed rule is appropriate because, as explained above, the exposure profiles and meteorological conditions in Alaska with respect to GHGs are significantly different in the state than in other areas of the United States and reasonably require the regulations in order to protect human health, welfare, and the environment.[922] Climate change is warming Alaska at twice the average global rate.[923] Further, implementation and enforcement of the proposed regulations is both technologically and economically feasible.[924]

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[918] *See* Michael J. Coffey, *Addressing Climate Change Impacts in Alaska Communities*, ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES, http://climatechange.alaska.gov/docs/afe11/DOTPF_coffey_feb11.pdf.
[919] *See* Trish Opheen, *U.S. Army Corps of Engineers Activities: Infrastructure and Coastal Erosion* (Feb. 2011) http://climatechange.alaska.gov/docs/afe11/USCOE_opheen_feb11.pdf.
[920] *See ADEC Presentation*, *supra* note 5, at 68 (Stating that "DEC can lead the regulatory functions of reducing emissions. Life style changes, energy use, community and economic challenges are best stimulated or managed by other state agencies: DCCED, DNR, Revenue, RCA, AOGCC.").
[921] *Id*.
[922] ALASKA STAT. ANN. § 46.14.010(c), (d) (West 2016).
[923] Kat Sorenson, *Alaska Continues to Warm at Twice the Global Rate*, PENINSULA CLARION (Apr. 25, 2017), http://peninsulaclarion.com/news/2017-04-25/alaska-continues-warm-twice-global-rate.
[924] ALASKA STAT. ANN. § 46.14.010(c)(2), (3) (West 2016); *see* Jacobson, *supra* note 787; The Solutions Project, *supra* note 844; *See* Section VI.B.7 *infra* (re: economic feasibility).

The Department's statutory obligations must be considered in the context of the Public Trust Doctrine and the Alaska Constitution. As one court in Washington has explained, an agency's statutory duty "must be understood in the context not just of the [State's] Clean Air Act itself but in recognition of the Washington Constitution and the Public Trust Doctrine."[925] Accordingly**,** given the aforementioned grants of authority, description of obligations, and statements of policy, Petitioners respectfully request that the Department adopt the proposed rule. Cumulatively, the proposed rule will allow Alaska to its part in achieving emission reductions on the scale necessary to avert disastrous consequences and substantial impairment to public trust resources. Failure to take immediate action to significantly reduce carbon dioxide emissions will increase the cost and magnitude of future reduction requirements and, more significantly, will result in catastrophic and irreversible adverse effects on petitioners, children, and future generations of Alaskans.

Alaska and the Departments' historic and continuing actions of permitting, authorizing, and incentivizing the development, extraction, combustion, and transportation of fossil fuels and other emissions-producing activities have substantially contributed to and caused the current climate crisis in violation of Petitioners' Public Trust and constitutional rights. In further violation of Petitioners' rights, notwithstanding its clear duty, the Department has yet to meet its obligation to adopt and enforce regulations that would reduce the state's GHG emissions by amounts needed to help secure a healthy atmosphere and stable climate and protect the public natural resources of the state. Petitioners respectfully request that the Department adopt the proposed rule so that ADEC and the state can remedy the violations of Petitioners' fundamental rights and fulfill their obligation to ensure that Alaska do its share in achieving emissions reductions necessary to preserve a stable climate system and avert the worst consequences of the current climate crisis.[926]

[925] *Foster v. Wash. Dep't of Ecology*, No. 14-2-25295-1, slip op. at 6 (Wash. King Cty. Super. Ct. Nov. 19, 2015), https://static1.squarespace.com/static/571d109b04426270152febe0/t/57607fe459827eb8741a852c/1465941993492/15.11.19.Order_FosterV.Ecology.pdf.

[926] The proposed rule requests ADEC to require emissions reductions from Alaska consistent with targets based on the global average emissions reductions required to remedy our climate emergency without accounting for the differentiated and equitable responsibilities of individual states and their historic contribution to carbon pollution. Alaska's per capita emissions are amongst the highest in the nation. *See* U.S. Energy Information Administration, *Energy-related Carbon Dioxide Emissions at the State Level, 2000-2014* (Jan. 17, 2017) https://www.eia.gov/environment/emissions/state/analysis/. In turn, the United States is the historically largest emitter of CO_2, the current second-largest emitter, and its per capita emissions are the greatest in the world. *See* Hansen, *Young People's Burden*, *supra* note 109 at 29. Accordingly, were Alaska to adopt a rule accounting for its historic equitable responsibility for the current climate crisis relative to other states and countries, such a rule would likely require *more* stringent emissions reductions than those proposed by Petitioners.