INCREASING MITIGATION AMBITION: ESTABLISHING "MITIGATION REFERENCE POINTS" TO TRIGGER MANDATORY GREENHOUSE GAS REDUCTIONS

BY

CHRIS WOLD* & AMELIA SCHLUSSER**

Parties to the United Nations Framework Convention on Climate Change (UNFCCC) pledged in the Cancun Agreements to reduce their greenhouse gas (GHG) emissions by certain percentages or take other action to limit their GHG emissions. However, at the 2011 climate change negotiations in Durban, they acknowledged the "significant gap" between their pledges and the goal of limiting global average temperature below 2°C above pre-industrial levels—the stated goal of the climate regime. The United Nations Environment Programme concluded that, in 2020, the pledges included in the Cancun Agreements will be eight to thirteen $GtCO_2e$ short of the 2°C goal. To bridge this gap, Parties must raise their level of ambition and make additional mitigation commitments to avoid the worst impacts of climate change. Yet, they have made no progress to increase their mitigation ambition before 2020 when the Cancun pledges expire or after 2020 as part of any new agreement under the Durban Platform.To increase ambition before 2020, Parties should adopt "mitigation reference points" that trigger automatic, predetermined mitigation action by Parties. Modeled on the precautionary reference points found in fisheries regimes, these reference points could include, for example, atmospheric GHG concentrations or global average temperatures reaching a specific target. When a reference point is reached or exceeded, automatic action, such as increasing mitigation commitments by some specified amount, would be required. The pre-determined actions triggered by mitigation reference points could take a variety of forms. They could require prorated or sector-specific emissions reductions. They could require all Parties to undertake the same action or be tailored according to Parties' past and present emission rates and mitigation capacities. Regardless, these mitigation actions must be predetermined, mandatory, and result in a measurable

* Professor of Law and Director, International Environmental Law Project (IELP), Lewis & Clark Law School, 10015 SW Terwilliger Blvd., Portland, OR 97219; wold@lclark.edu.
** Energy Fellow, the Green Energy Institute at Lewis & Clark Law School.

decrease in GHG emissions or a measurable increase in sequestration capacity.

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I. INTRODUCTION

As part of the Cancun Agreements[1] of the United Nations Framework Convention on Climate Change (UNFCCC),[2] States pledged to reduce their greenhouse gas (GHG) emissions by certain percentages or take other action to limit their GHG emissions.[3] However, at the 2011 climate change negotiations in Durban, the Parties acknowledged the "significant gap" between their pledges to reduce GHG emissions by 2020 and the goal of limiting global average temperature below 2°C or 1.5°C above pre-industrial levels.[4] The United Nations Environment Programme (UNEP) concluded that, in 2020, the current mitigation pledges included in the Cancun

1 The Cancun Agreements: Outcome of the Work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention, Decision 1/CP.16, U.N. Doc. FCCC/CP/2010/7/Add.1 (Mar. 15, 2011) [hereinafter Cancun Agreements].

2 United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 107 [hereinafter FCCC].

3 Cancun Agreements, Compilation of Economy-wide Emission Reduction Targets to Be Implemented by Parties Included in Annex I to the Convention, U.N. Doc. FCCC/SB/2011/INF.1/Rev.1 (June 7, 2011).

4 United Nations Framework Convention on Climate Change, Conference of the Parties, Durban, S. Afr., Nov. 28–Dec. 11, 2011, *Report of the Conference of the Parties on its Seventeenth Session*, Addendum, *Part Two: Action Taken by the Conference of the Parties at Its Seventeenth Session*, 2, U.N. Doc. FCCC/CP/2011/9/Add.1 (Mar. 15, 2012), *available at* http://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf.

Agreements will be eight to twelve $GtCO_2e$ short[5] of limiting average global temperature increases to 2°C above preindustrial levels—the stated goal of the climate regime.[6]

To bridge this gap, UNFCCC Parties must raise their level of ambition and make additional mitigation commitments before any new agreement under the Durban Platform comes into effect in 2020.[7] Yet, they have struggled to do so.[8] As the clock ticks toward 2015, when UNFCCC Parties have agreed to conclude new pledges to mitigate climate change that would take effect in 2020,[9] the Parties have made little progress.[10] Moreover, they have made no progress on increasing ambition before 2020, although they have established a program of work for doing so.[11]

One strategy for increasing ambition before 2020 is to adopt "mitigation reference points" that would trigger automatic pre-determined mitigation action by the Parties.[12] These reference points could include, for example, atmospheric GHG concentrations reaching a specific threshold, global average temperatures rising to a specified level, ice sheets melting at a particular rate, and sea level rising to a certain point. When a reference point is reached or exceeded, automatic action, such as increasing commitments by an equal or prorated amount, would be required. As discussed in Sections II and III, the strategy is modeled on the precautionary reference points that have been established by the U.N. Fish Stocks Agreement,[13] which has embraced them to avoid overfishing. Sections IV and V describe how

5 U.N. ENV'T PROGRAMME, THE EMISSIONS GAP REPORT 2012: A UNEP SYNTHESIS REPORT 1 (2012), *available at* http://www.unep.org/publications/ebooks/emissionsgapreport2013/ [hereinafter UNEP, Emissions Gap Report 2012].

6 Cancun Agreements, *supra* note 1, ¶ 4.

7 *Id.* ¶ ¶ 36–47.

8 U.N. ENV'T PROGRAMME, BRIDGING THE EMISSIONS GAP: A UNEP SYNTHESIS REPORT, 21–25 (2011) *available at* http://www.unep.org/pdf/2012gapreport.pdf.

9 The UNFCCC Parties agreed "to develop a protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties" and to complete their work "as early as possible but no later than 2015 in order to adopt this protocol, another legal instrument or an agreed outcome with legal force at the twenty-first session of the Conference of the Parties [in 2015] and for it to come into effect and be implemented from 2020." Framework Convention on Climate Change, Report of the Conference of the Parties on its seventeenth session, Nov. 28–Dec. 11, 2011, *Establishment of an Ad Hoc Working Group on the Durban Platform for Enhanced Action*, ¶¶ 2, 4, Decision 1/CP.17 (Mar. 15, 2012).

10 U.N. ENV'T PROGRAMME, BRIDGING THE EMISSIONS GAP: A UNEP SYNTHESIS REPORT, 43–44 (2012), *available at* http://www.unep.org/publications/ebooks/emissionsgap2012/.

11 *See* Decision 1/CP.17, Establishment of an Ad Hoc Working Group on the Durban Platform for Enhanced Action, U.N. Doc. FCCC/CP/9/Add.1 (Mar. 15, 2012).

12 *See infra* Sections IV, V.

13 United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, U.N. Gen. Assembly, New York, U.S., July 24–Aug. 4, 1995, *Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea Of 10 December 1982, Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks*, A/Conf. 164/37, (Sept. 8, 1995), *available at* http://www.un.org/depts/los/convention_agreements/texts/fish_stocks_agreement/CONF164_37.htm [hereinafter Fish Stocks Agreement].

"mitigation reference points" could be developed to increase ambition within the climate change regime.

II. REFERENCE POINTS IN FISHERIES REGIMES

The UN Food and Agriculture Organization (FAO) estimates that 57% of marine fish stocks were fully exploited in 2009 and 30% were overexploited,[14] conditions that have significantly worsened since 1974.[15] To halt the continued overexploitation of marine fish stocks, the Fish Stocks Agreement grants coastal states, among other things, new enforcement and inspection powers.[16] In addition, it requires states to "apply the precautionary approach widely to conservation, management and exploitation of straddling fish stocks and highly migratory fish stocks."[17] To implement the precautionary approach, the Fish Stocks Agreement directs states to "implement[] improved techniques for dealing with risk and uncertainty"[18] and to "be more cautious when information is uncertain, unreliable or inadequate."[19]

To address risk and uncertainty more effectively and to act more cautiously, the Fish Stocks Agreement mandates that states adopt "precautionary reference points."[20] Precautionary reference points guide fisheries management by estimating stock-specific values that correspond to

14 U.N. FOOD & AGRICULTURE ORG., THE STATE OF WORLD FISHERIES AND AQUACULTURE 2012, at 11 (2012) [hereinafter FAO, State of World Fisheries].

15 The FAO reports that:

> The proportion of non-fully exploited stocks has decreased gradually since 1974 when the first FAO assessment was completed. In contrast, the percentage of overexploited stocks has increased, especially in the late 1970s and 1980s, from 10 percent in 1974 to 26 percent in 1989. After 1990, the number of overexploited stocks continued to increase, albeit at a slower rate. Increases in production from these overexploited stocks may be possible if effective rebuilding plans are put in place. The fraction of fully exploited stocks, which produce catches that are very close to their maximum sustainable production and have no room for further expansion and require effective management to avoid decline, has shown the smallest change over time, with its percentage stable at about 50 percent from 1974 to 1985, then falling to 43 percent in 1989 before gradually increasing to 57 percent in 2009. About 29.9 percent of stocks are overexploited, producing lower yields than their biological and ecological potential and in need of strict management plans to restore their full and sustainable productivity . . . .

Id.

16 Fish Stocks Agreement, *supra* note 13, art. 21. ("In any high seas area covered by a subregional or regional fisheries management organization or arrangement, a State Party which is a member of such organization or a participant in such arrangement may . . . board and inspect . . . fishing vessels flying the flag of another State Party to this Agreement, whether or not such State Party is also a member of the organization or a participant in the arrangement, for the purpose of ensuring compliance with conservation and management measures for straddling fish stocks and highly migratory fish stocks established by that organization or arrangement.").

17 *Id.* art. 6.1.

18 *Id.* art. 6.3(a).

19 *Id.* art. 6.2.

20 *Id.* art. 6.3(b).

the state of the resource and the relevant fishery.[21] The Fish Stocks Agreement identifies two types of precautionary reference points. Conservation, or limit, reference points "set boundaries which are intended to constrain harvesting within safe biological limits within which the stocks can produce maximum sustainable yield."[22] The Agreement further specifies that the minimum standard for limit reference points should be "[t]he fishing mortality rate which generates maximum sustainable yield" and that fishing mortality must not fall below this level.[23] In the Northeast Atlantic, where 62% of stocks are fully exploited and 31% are overexploited, maximum sustained yield was recently adopted as the standard limit reference point.[24]

Management, or target, reference points are intended to meet management objectives.[25] For example, the Commission for Conservation of Antarctic Marine Living Resources—a Regional Fisheries Management Organization (RFMO)—limits icefish harvest to "an annual yield which results in a 5% probability that the spawning stock biomass is reduced to below 75% of the level that would occur in the absence of fishing over a two-year projection period."[26] In other words, limit reference points identify biological harvest limits, while target reference points establish additional management objectives within the identified harvest limit.[27]

Precautionary reference points are more than identified thresholds—they also introduce an important management mandate: States must identify the action to be taken if a stock-specific reference point is exceeded[28] because precautionary reference points "trigger pre-agreed conservation and management action."[29] For example, if a precautionary reference point relates to a fish stock reaching a specific biomass or a harvest reaching a certain tonnage, the State adopting the reference point must take whatever management action has been pre-agreed if the reference point is met or exceeded.[30] As the Fish Stocks Agreement provides, if a reference point is reached or exceeded, "States shall, without delay, take the action [previously agreed] to restore the stocks,"[31] the "absence of adequate scientific information shall not be used as a reason for postponing or failing to take

21 *Id.* Annex II, ¶¶ 1, 3.

22 *Id.* ¶ 2.

23 *Id.* ¶ 7. FAO defines maximum sustainable yield as "the maximum catch that can be obtained on a sustained basis." U.N. Food & Agriculture Org., Fisheries and Aquaculture Dept., *Brief Review of the Basic Concepts of Fishery Management*, http://www.fao.org/docrep/003/x6844e/X6844E02.htm (last visited Feb. 15, 2014).

24 FAO, State of World Fisheries, *supra* note 14, at 58.

25 Fish Stocks Agreement, *supra* note 13, Annex II, ¶ 2.

26 Comm'n for Conservation of Antarctic Marine Living Res., *Setting Catch Limits,* http://www.ccamlr.org/en/fisheries/setting-catch-limits (last visited Feb. 15, 2014).

27 *See* Fish Stocks Agreement, *supra* note 13, Annex II, ¶ 2; GERD WINTER, TOWARDS SUSTAINABLE FISHERIES LAW: A COMPARATIVE ANALYSIS, Int'l Union for Conservation of Nature Envtl. Policy and L. Paper no. 74, 9 (2009), *available at* http://www.iucn.org/about/work/programmes/environmental_law/elp_resources/elp_res_publications/?uPubsID=3873.

28 Fish Stocks Agreement, *supra* note 13, art. 6.3(b).

29 *Id.* Annex II, ¶ 4.

30 *Id.*

31 *Id.* art. 6.4.

conservation and management measures."[32] This concept—that overexploitation of a natural resource must trigger immediate remedial action—could be integrated into the climate change regime to increase mitigation ambition.

III. LESSONS LEARNED FROM IMPLEMENTATION OF PRECAUTIONARY REFERENCE POINTS

Stock-specific reference points are used in fisheries management at both national and regional levels, but these precautionary thresholds have largely failed to prevent overexploitation of marine fisheries even though a majority of FAO Member States and RFMOs have incorporated precautionary reference points into their fisheries management plans.[33] FAO reports that two-thirds of regional fishery bodies[34] use stock-specific reference points, but that a majority of these reference points were either being approached or have been exceeded.[35] In fact, over-fishing is a worldwide problem resulting from poor fisheries management at the national and regional levels, with nearly 30% of global marine stocks currently overexploited.[36] At the regional level, TRAFFIC has concluded that "[i]t is difficult to identify examples of sustainable management of target stocks by RFMOs. Many stocks are over-fished despite the objectives of the responsible organization."[37] At a national level, more than half of FAO Member States have established stock-specific reference points, but most of these thresholds have been approached or exceeded as well; 68% of managed fisheries are overexploited.[38] In many ways, the failure of reference points is not surprising: The FAO reported in 2009 that FAO Members

32 *Id.* art. 6.2.

33 *See* U.N. Food & Agriculture Org., Committee on Fisheries, *Progress in the Implementation of the Code of Conduct for Responsible Fisheries and Related Instruments, Including International Plans of Action and Strategies, and Other Matters*, ¶¶ 14, 53 COFI/2012/3 (2012), *available at* http://www.fao.org/cofi/23150-0eeccd1587da098786f61fd0 8a7fe04cf.pdf [hereinafter FAO Committee on Fisheries 2012 Report]; s*ee also* FAO, State of World Fisheries, *supra* note 14, at 11 ("After 1990, the number of overexploited stocks continued to increase, albeit at a slower rate.").

34 FAO Committee on Fisheries 2012 Report, *supra* note 33, ¶ 53. Regional Fisheries Bodies (RFBs) are institutions through which States and organizations conserve, manage, and develop fisheries. RFBs fall into three categories. First, RFBs can manage fisheries resources in a particular region. These are typically called Regional Fisheries Management Organization (RFMOs). Second, RFBs may be advisory bodies. Third, they may be Scientific Bodies, gathering information about fisheries and providing relevant information to RFMOs, governments, and others. Int'l Game Fish Ass'n, *Regional Fisheries Bodies*, http://www.igfa.org/Conserve/RFBs.aspx (last visited Feb. 15, 2014).

35 FAO Committee on Fisheries 2012 Report*, supra* note 33, ¶ 53.

36 FAO, State of World Fisheries, *supra* note 14, at 11.

37 A. WILLOCK & M. LACK, FOLLOW THE LEADER: LEARNING FROM EXPERIENCE AND BEST PRACTICE IN REGIONAL FISHERIES MANAGEMENT ORGANIZATIONS 11 (2006), *available at* www.traffic.org/fisheries-reports/traffic_pub_fisheries3.pdf.

38 FAO Committee on Fisheries 2012 Report*, supra* note 33, ¶ 14.

ranked stock-specific reference points as the Member's lowest priority fisheries management measure.[39]

Three significant reasons have contributed to the lack of success of precautionary reference points. First, technical and scientific concepts like "precautionary reference points" do not appear to be clearly understood by all fisheries managers.[40] For example, African, Asian and European countries listed fishing gear controls as an indicator of stock health rather than a basic management measure.[41] Second, very few RFMOs have developed mandatory management actions that must be undertaken when precautionary reference points are exceeded.[42] Without such a framework, RFMOs are able to justify their failure to take precautionary action on the basis of uncertainty, cost, or stock allocation issues.[43] Third, RFMOs have failed to set precautionary reference points or implement responsive management action in instances where stock population status is uncertain or unknown,[44] even though the Fish Stocks Agreement mandates that States "be more cautious when information is uncertain, unreliable or inadequate."[45] In instances where RFMOs have received scientific advice urging precautionary action due to uncertain or unavailable stock data, RFMOs have responded by noting the recommendations, requesting additional analysis, or seeking additional advice regarding potential management responses.[46]

While these shortfalls may hinder efforts to prevent overexploitation of global fisheries, they provide valuable insight into the precautionary reference point model that could be incorporated into an international climate change agreement. First, precautionary reference points should be established at the international level as determined and agreed upon by all Parties. In the fisheries context, the regional variation among fisheries supports the regional establishment of reference points because even fish stocks of the same species may exhibit varying degrees of productivity depending on location.[47] For example, tuna stocks are more productive in the cooler waters of the equatorial eastern Pacific, but a higher percentage of the tuna catch occurs in the warmer waters of the equatorial western

39 Gilles Hosch, *Analysis of the Implementation and Impact of the FAO Code of Conduct for Responsible Fisheries Since 1995,* FAO Fisheries and Aquaculture Circular No. 1038 at 23, tbl.5, 24, FIEL/C1038 (En) (2009), *available at* ftp://ftp.fao.org/docrep/fao/011/i0604e/i0604e00.pdf.

40 *Id.* at 24.

41 *Id.*

42 WILLOCK & LACK, *supra* note 37, at 14 ("Very few RFMOs have developed management strategies, including decision-making frameworks based on precautionary reference points, for target stocks.").

43 *Id.* at 13.

44 *Id.*

45 Fish Stocks Agreement, *supra* note 13, art. 6.2.

46 WILLOCK & LACK, *supra* note 37, at 13.

47 Thierry Oberdorff et al., *Global and Regional Patterns of Riverine Fish Species Richness: A Review*, INTERNATIONAL JOURNAL OF ECOLOGY, 2011, *available at* http://www.hindawi.com/journals/ijecol/2011/967631/.

Pacific.[48] In contrast, GHG concentrations are relatively constant throughout the atmosphere and impacts are independent of where GHGs are emitted.[49] This global consistency therefore supports the establishment of precautionary reference points at an international level.

Second, precautionary mitigation actions should be established by the Parties to correspond with specific precautionary reference points. These precautionary measures do not have to apply equally to all Parties in order to be effective, but they should reflect as much of a consensus as possible. When a reference point is exceeded, all Parties must understand what additional obligations they would be subject to. Parties cannot be afforded any flexibility in implementing these mandatory mitigation actions.

Third, the Parties must develop an international mechanism to hold Parties accountable for failure to implement precautionary measures if a reference point is exceeded. Precautionary reference points cannot be effective if Parties refuse to implement them.

Fourth, it is imperative that a lack of scientific certainty not be used to justify a failure to implement precautionary measures. Reference point thresholds must either be verifiable with a great degree of accuracy or must explicitly account for and allow scientific uncertainty. For example, if a reference point is based on atmospheric GHG concentrations reaching a certain level, the Parties must agree on the data collection and modeling methods and parameters that will be used to measure global concentrations—e.g., from a single or multiple points, for a day or over some other specified period of time. In contrast, if a reference point is based on impacts that are not easily measured or are plagued by uncertainty, this uncertainty should be accounted for in a manner acceptable to the Parties. For example, average global temperatures have been steadily increasing over the past century, yet average annual temperatures may fluctuate from year to year.[50] July 2012 was the hottest July on record—land surface temperatures in the Northern Hemisphere were 2.14°F (1.19°C) above average.[51] However, March 2013 was substantially colder than average in most areas of the United States, while temperatures in March 2012 were

48 Valérie Allain et al., *Trophic Structure and Tuna Movement in the Cold Tongue-Warm Pool Pelagic Ecosystem of the Equatorial Pacific*, *in* PROCEEDINGS OF THE 55TH ANNUAL TUNA CONFERENCE, LAKE ARROWHEAD, CALIFORNIA, MAY 24–27, 2004, CHARACTERIZING PRODUCTIVITY OF HIGHLY MIGRATORY FISH POPULATIONS IN THE CONTEXT OF PROVIDING "GOOD" MANAGEMENT ADVICE, *available at* http://media.wix.com/ugd//ba25d2_927d3b9b32939f99f3f78d00e9d374cc.pdf.

49 *See, e.g.*, Seth Borenstein, *Climate Change: Arctic Passes 400 Parts Per Million Milestone*, CHRISTIAN SCI. MONITOR, May 31, 2012, http://www.csmonitor.com/Science/2012/0531/Climate-change-Arctic-passes-400-parts-per-million-milestone (last visited Feb. 22, 2014) (explaining that while stations throughout the Arctic are measuring about 400 parts per million (ppm) of CO_2 in the atmosphere, the global average is 395 ppm, but will likely increase to 400 ppm within the next few years).

50 Nat'l Oceanic & Atmospheric Admin., *Climate at a Glance: Time Series*, http://www.ncdc.noaa.gov/cag/time-series/global (last visited Feb. 22, 2014).

51 Nat'l Oceanic & Atmospheric Admin., *State of the Climate: Global Analysis July 2012*, http://www.ncdc.noaa.gov/sotc/global/2012/7 (last visited Feb. 22, 2014).

much higher than average in most of the country.[52] In order to be effective, a reference point based on average temperature increases would need to acknowledge potential variation in annual averages, with Parties agreeing how average temperatures will be measured.

In the alternative, the Parties could create a rebuttable presumption that precautionary action will be required in spite of scientific uncertainty. In this scenario, a Party could rebut a determination that a reference point had been exceeded by presenting scientific evidence to the contrary. In the fisheries context, this novel variation of the precautionary approach has been applied by the U.S. North Pacific Fishery Management Council (NPFMC).[53] In 2009, the NPFMC[54] "clos[ed] 150,000 square nautical miles to commercial fishing."[55] Although the fishery had not yet been subject to commercial exploitation—and consequently no precautionary reference point had been reached or exceeded—the NPFMC expected that commercial fishing would occur at some point in the future due to the effects of climate change on the Arctic Management Area (AMA),[56] an area of the marine environment that includes the portions of the Beaufort and Chukchi seas within the United States' Exclusive Economic Zone (EEZ).[57] The NPFMC acknowledged that there was substantial scientific uncertainty regarding the status of fish stocks in the AMA and "opted to preemptively close it to commercial fishing to avoid unregulated development and its possible adverse effects on the ecosystem."[58] Given the absence of scientific data, the NPFMC presumed the fishery could not sustain exploitation, rather than presume the opposite and risk potentially devastating consequences.[59] Climate change mitigation policy would benefit from such an approach.

IV. MITIGATION REFERENCE POINTS IN THE CLIMATE CHANGE CONTEXT

Despite the flawed implementation of precautionary reference points in the fisheries context, the reference points concept provides a useful mechanism for increasing ambition both before 2020, as States implement their obligations under the Cancun Agreements and the Kyoto Protocol's second commitment period, and after 2020, when new commitments are

52 Nat'l Oceanic & Atmospheric Admin., *In Stark Contrast to Last Year, March 2013 Cooler than Average in the U.S.*, http://www.climate.gov/news-features/featured-images/stark-contrast-last-year-march-2013-cooler-average-us (last visited Feb. 22, 2014).

53 Sarah M. Kutil, *Scientific Certainty Thresholds in Fisheries Management: A Response to a Changing Climate*, 41 ENVTL. L. 233, 235, 249 (2011).

54 The NPFMC is a Regional Fishery Management Council that derives its authority under the Magnuson-Stevens Fishery Conservation and Management Act. The Act is implemented by the National Marine Fisheries Service (NMFS), which regulates the NPFMC. *See* Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. § 1852(a)–(b) (2006).

55 Kutil, *supra* note 53, at 234.

56 *Id.*

57 N. PAC. FISHERY MGMT. COUNCIL, FISHERY MANAGEMENT PLAN FOR FISH RESOURCES OF THE ARCTIC MANAGEMENT AREA 1–2 (2009), *available at* http://www.npfmc.org/wp-content/PDFdocuments/fmp/Arctic/ArcticFMP.pdf.

58 Kutil, *supra* note 53, at 235.

59 *Id.* at 237–38.

expected to take effect.[60] As noted above,[61] the commitments made by States as part of the Cancun Agreements are inadequate to achieve the climate regimes goal of maintaining average global temperatures 2°C below pre-industrial levels.[62] In Durban in 2011, the UNFCCC Parties established the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP) and tasked it with developing a new climate agreement that establishes post-2020 emissions reduction commitments and creating a workplan to increase mitigation ambition prior to 2020.[63] The ADP subsequently adopted two workstreams: workstream 1 focuses on developing post-2020 commitments through a new climate agreement, and workstream 2 focuses on increasing pre-2020 mitigation ambition.[64] Precautionary reference points could be incorporated into both ADP workstreams to trigger additional emissions reductions.

A mitigation reference point system could be effectively incorporated into future climate change agreements, as long as the reference points effectively account for scientific uncertainty and the predetermined mitigation actions consist of measurable, enforceable mitigation actions. In accounting for uncertainty, mitigation reference points must take positive feedback mechanisms into account because these mechanisms may accelerate the rate of global warming.[65] Section A examines several potential mitigation reference points that could be incorporated into future climate change agreements. Section B discusses the significance of positive feedback mechanisms.

A. Mitigation Reference Points

A variety of reference points could be established under the international climate change regime.[66] The overarching objective of the UNFCCC framework is to prevent global temperatures from increasing 2ºC

60 *See* Framework Convention on Climate Change, Conference of the Parties: Seventeenth Session, Durban, S. Afr., Nov. 28–Dec. 9, 2011, *Establishment of an Ad Hoc Working Group on the Durban Platform for Enhanced Action*, ¶¶ 4–8, U.N. Doc. FCCC/CP/2011/L.10 (Dec. 10, 2011), *available at* http://unfccc.int/resource/docs/2011/cop17/eng/l10.pdf [hereinafter Durban Platform].

61 *See supra* Part I and notes 1–6.

62 Cancun Agreements, *supra* note 1, ¶ 4.

63 Durban Platform, *supra* note 60, ¶¶ 2, 4, 6–7.

64 Ad Hoc Working Grp. on the Durban Platform for Enhanced Action, *Summary of the Roundtable under Workstream 1*, Nov.–Dec. 2012, ADP/2012/6/InformalSummary ¶¶ 1, 5 (Feb. 7, 2013); Ad Hoc Working Grp. on the Durban Platform for Enhanced Action, *Summary of the Roundtable on Workstream 2*, Nov.–Dec. 2012, ADP/2012/7/InformalSummary ¶¶ 1, 3 (Feb. 3, 2013).

65 Hamish Johnston, *Cloud Feedback Could Accelerate Global Warming*, PHYSICS WORLD, July 23, 2009, http://physicsworld.com/cws/article/news/2009/jul/23/cloud-feedback-could-accelerate-global-warming (last visited Feb. 22, 2014).

66 Intergovernmental Panel on Climate Change, *Climate Change 2007: Working Group III: Mitigation of Climate Change*, *available at* http://www.ipcc.ch/publications_and_data/ar4/wg3/en/spmsspm-e.html.

above pre-industrial levels.[67] Scientists have estimated that global atmospheric GHG concentrations of 450 ppm CO_2equivalent (eq)[68] would result in a temperature increase of around 2.1°C, and stable concentrations of 415 ppm or less would likely prevent a temperature rise of 2°C.[69] In order to maintain concentrations below this amount, global GHG emissions should average 37 $GtCO_2eq$/year by 2030, and 21 $GtCO_2eq$/year by 2050.[70] To reach these emissions targets, precautionary reference points could be established for specific increases in atmospheric GHG concentrations or for annual global emissions. For example, if atmospheric CO_2eq concentrations exceed 415 ppm before a specific date, it would trigger a requirement that Parties implement additional emissions reduction measures.

1. Atmospheric GHG Concentrations

An atmospheric CO_2eq concentration of 415 ppm is one potential mitigation reference point to trigger mandatory emissions reductions.[71] More specifically, if atmospheric CO_2eq concentrations average 415 ppm over a seven-day period, States would be obligated to take immediate action to decrease emissions. Atmospheric CO_2eq concentrations work well as a precautionary reference point for a number of reasons. First, GHG concentrations are relatively easy to measure, and they are dispersed relatively evenly throughout the global atmosphere.[72] Second, because

67 *See* FCCC, *supra* note 2. *See also* NASA: EARTH OBSERVATION, HOW WILL GLOBAL WARMING CHANGE EARTH?, *available at* http://earthobservatory.nasa.gov/Features/GlobalWarming/page6.php.

68 Real Climate, *CO2 Equivalents*, http://www.realclimate.org/index.php/archives/2007/10/co2-equivalents (last visited Feb. 22, 2014). Scientists measure concentrations of GHGs relative to the warming potential of CO_2. For example, methane has a warming potential over a 100-year period that is 25 times greater than CO_2. Using these figures for each GHG, scientists then convert the warming impact of emissions levels for the individual GHGs into a CO_2 equivalent amount so that the warming potential of GHG emissions can be compared more easily. For this reason, the 450 ppm CO_2eq goal should not be confused with the oft-stated goal of reducing CO_2 concentrations to 350 ppm. The former goal refers to concentrations of all GHGs whereas the latter refers only to CO_2. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: WORKING GROUP I: THE PHYSICAL SCIENCE BASIS (2007), *available at* http://www.ipcc.ch/publications_and_data/ar4/wg1/en/tssts-2-5.html; Climate Change Connection, *CO2 Equivalents*, http://www.climatechangeconnection.org/emissions/CO2_equivalents.htm (last visited Feb. 22, 2014).

69 U.N. ENV'T PROGRAMME, BRIDGING THE EMISSIONS GAP: A UNEP SYNTHESIS REPORT 17 (2011), [hereinafter UNEP, BRIDGING THE GAP] *available at* http://www.unep.org/pdf/unep_bridging_gap.pdf.

70 U.N. ENV'T PROGRAMME, THE EMISSIONS GAP REPORT 2012: A UNEP SYNTHESIS REPORT 3 (2012), [hereinafter UNEP, EMISSIONS GAP REPORT 2012] *available at* www.unep.org/pdf/2012gapreport.pdf.

71 *See* UNEP, BRIDGING THE GAP, *supra* note 69, at 17 (discussing how GHG equilibrium would be achieved by limiting CO_2e concentrations to 415 ppm).

72 Nat'l Aeronautics & Space Admin., *Methane's Impacts on Climate Change May Be Twice Previous Estimates*, *available at* http://www.nasa.gov/centers/goddard/news/topstory/2005/methane_prt.htm (last visited Feb. 22, 2014). Atmospheric GHG concentrations can differ in different areas of the globe. For example, in Spring 2012, average global CO_2 concentrations reached 395 ppm, but CO_2 concentrations above the Arctic Circle reached 400 ppm. Seth

atmospheric CO_2eq concentrations include both anthropogenic and non-anthropogenic emissions, this goal accounts for non-anthropogenic CO_2eq emissions resulting from positive feedback mechanisms in addition to anthropogenic emissions.[73] For example, permafrost is thawing as a result of global temperature increases, and as it thaws it releases CO_2 and methane, which is a potent GHG.[74] However, it is extremely difficult to project the rate or amount of future emissions that will result from permafrost thaw and other comparable feedback mechanisms.[75] As a result of this uncertainty, these emissions may not be accurately accounted for in many climate models or the emissions inventories submitted by Parties.[76] However, equipment measuring CO_2eq trends would measure concentrations resulting from emissions from any source.

To ensure the accuracy of a 415 ppm measurement, atmospheric CO_2eq concentration measurements should be averaged from one pre-determined location. NOAA's Mauna Loa Observatory (MLO) is an atmospheric baseline station that has continuously monitored and collected atmospheric data since the 1950s, and is an ideal location for measuring CO_2eq concentrations due to its high altitude and remote location in the Pacific.[77] High amounts of vegetation or industrial activity can affect atmospheric measurements, and the MLO's island location avoids these impacts.[78] In addition, MLO's readings are "a fairly good approximation for what global concentrations are, although it is slightly higher than the global average because it is in the Northern Hemisphere, which generally has higher CO_2 concentrations."[79]

Climate researchers have largely determined that atmospheric CO_2eq concentrations must remain below 450 ppm in order to prevent more than a

Borenstein, *Climate Change: Arctic Passes 400 Parts per Million Milestone*, CHRISTIAN SCI. MONITOR, May 31, 2012, http://www.csmonitor.com/Science/2012/0531/Climate-change-Arctic-passes-400-parts-per-million-milestone (last visited Feb. 22, 2014).

73 *See generally* John W. Farley, *The Scientific Case for Modern Anthropogenic Global Warming*, MONTHLY REVIEW, July–Aug. 2008, http://monthlyreview.org/2008/07/01/the-scientific-case-for-modern-anthropogenic-global-warming (last visited Feb. 22, 2014) (discussing positive mechanisms related to greenhouse gas emissions).

74 *See* NAT'L RESEARCH COUNCIL, CLIMATE STABILIZATION TARGETS: EMISSIONS, CONCENTRATIONS, AND IMPACTS OVER DECADES TO MILLENIA 222 (2011) [hereinafter NRC, CLIMATE STABILIZATION TARGETS].

75 *See What Are Climate Change Feedback Loops?,* THEGUARDIAN.COM, Dec. 17, 2010, http://www.theguardian.com/environment/2011/jan/05/climate-change-feedback-loops (last visited Feb. 22, 2014) [hereinafter Climate Change Feedback Loops].

76 See *id.*

77 NOAA Earth System Research Lab. Global Monitoring Div., *About Mauna Loa Observatory*, http://www.esrl.noaa.gov/gmd/obop/mlo/aboutus/aboutus.html (last visited Feb. 22, 2014).

78 Stephanie Paige Ogburn & ClimateWire, *As Co_2 Concentrations Near Ominous Benchmark, Daily Updates Begin*, SCIENTIFIC AMERICAN, Apr. 24, 2013, http://www.scientificamerican.com/article.cfm?id=as-co2-concentrations-near-ominous-benchmark-daily-updates-begin (last visited Feb. 22, 2014).

79 *Id.*

2ºC increase in global temperatures.[80] Under the International Energy Agency's (IEA) 450 Scenario, "global energy-related CO_2 emissions peak before 2020 and then decline to 21.6 Gt by 2035."[81] IEA cautions that action must be taken to further reduce emissions prior to 2017; if action is delayed until after 2017, then all new energy infrastructure built between 2017 and 2035 must have zero carbon emissions.[82] According to UNEP's projections, median GHG emissions must range between thirty-three to forty-four $GtCO_2e$ in 2030, and be less than twenty-five $GtCO_2e$ by 2050.[83] However, while both of these scenarios are based on emissions modeling using the best available science, they are still estimations that cannot be predicted with 100% accuracy.[84] Atmospheric GHG concentrations could rise more quickly than current projections indicate, in which case necessary emissions reductions would have to occur over a shorter time period than these scenarios suggest.[85] By utilizing precautionary reference points based on atmospheric GHG concentrations, emissions reduction measures would be automatically triggered in the event that concentrations rise more quickly than projected.

2. Sea Level Rise

Sea level rise could also serve as a mitigation reference point that would take some positive feedback mechanisms into account.[86] For example, a mitigation reference point of fifty centimeters rise in global sea levels could be established to trigger mandatory emissions reductions. Global sea levels are projected to rise 6.6 feet by 2100, and Scientists at the Potsdam Institute for Climate Change Research recently projected that global sea levels will rise an estimated 2.3 meters for every 1ºC increase in

80 *See* UNEP, BRIDGING THE GAP, *supra* note 69, at 17; INT'L ENERGY AGENCY, WORLD ENERGY OUTLOOK 2011 FACTSHEET (2011), [hereinafter IEA 2011 FACTSHEET] *available at* http://www.worldenergyoutlook.org/media/weowebsite/2011/factsheets.pdf.

81 IEA 2011 FACTSHEET, *supra* note 80.

82 *See id.*

83 UNEP, EMISSIONS GAP REPORT 2012, *supra* note 70, at 3.

84 *See generally* UNEP, EMISSIONS GAP REPORT 2012, *supra* note 70, at 1 (noting that global greenhouse gas emissions, based on 2010 data from bottom-up emission inventory studies, are estimated at 50.1 GtCO2e, with a 95% uncertainty range of 45.6–54.6).

85 *Id.* at 4, 12 (emphasizing that even if countries implement their "lower-ambition pledges and are subject to 'lenient' accounting rules," the median highest projections with minimum estimate of annual greenhouse gas emissions in 2020 is 57 GtCO2e, which is in turn, within a range of 56–57 GtCO2e where such range is at 20th–80th percentiles respectively, which if actual emissions exceed 80th percentile, will require even more aggressive measures than the report provides to close the target gap on time).

86 *See generally* Fen Montaigne Interview with Anders Levermann, lead author of the IPCC's upcoming 5th assessment report, in *Leaving Our Descendants a Whopping Rise in Sea Levels,* YALE ENVIRONMENT 360, July 24, 2013, http://e360.yale.edu/feature/leaving_our_descendants_a_whopping_rise_in_sea_levels/2675/ (last visited Feb. 22, 2014) (opining that a climate change "threshold" is a four to five inch increase in global oceanic levels before global social, political, and economic systems collapse due to the resulting instability caused by famine, natural disasters and forced emigration, but that while an increase of two inches is enviable given the CO_2 which has already, or will have been, deposited into the atmosphere, this leaves approximately two to three inches which can and should be mitigated).

temperature.[87] Sea levels have risen twenty centimeters in the past century, and this relatively slight increase has already had devastating consequences for many low-lying coastal areas throughout the world.[88] Sea level rise due to ice sheet melt is directly correlated with increases in global average temperatures, but sea level rise is also influenced by secondary feedback mechanisms that occur at both a global and a localized scale.[89] Precautionary reference points based on sea level rise would account for ice sheet melt, land-based glacier withdrawal, groundwater mining, and soil moisture loss.[90] Sea level rise is occurring at a faster rate than scientists initially projected,[91] and a precautionary reference point based on sea level thresholds would account for this temporal uncertainty.

One difficulty associated with using sea level rise as a mitigation reference point involves observed global variation in rates of sea level rise.[92] The U.S. Geological Survey (USGS) recently reported that sea level is rising three to four times faster along the eastern coast of the United States than it is throughout the rest of the world.[93] According to USGS, "[d]ifferences in land movements, strength of ocean currents, water temperatures, and salinity can cause regional and local highs and lows in sea level."[94] This regional variation could potentially influence political will to implement

87 *See id.* ("For every 1 degree Celsius of temperature increase, the world will eventually experience a 2.3-meter increase in sea level. That means that should carbon emissions continue to rise at or near current rates, and temperatures soar 4 to 5 degrees [Celsius] in the next century or two, the world could well experience sea level increases of many meters — dozens of feet— in the centuries and millennia to come.") The recently published Fifth Assessment by the Intergovernmental Panel on Climate Change (IPCC) provides a more conservative estimate of sea level rise, estimating that seas will likely rise between 0.26 and 0.98 meters (0.85 to 3.21 feet). IPCC, WORKING GROUP I CONTRIBUTION TO THE IPCC FIFTH ASSESSMENT REPORT: CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS: SUMMARY FOR POLICYMAKERS, SPM-18 (Sept. 27, 2013).

88 *See generally id.* ("Significant is very much defined here by society. The 20 centimeters [8 inches] that we have observed in the last 100 years are significant for the smaller island states in the Pacific, which are inevitably going to vanish in the future.").

89 *See, e.g.*, *supra* note 75 ("Because ice is light-colored and reflective, a large proportion of the sunlight that hits it is bounced back to space, which limits the amount of warming it causes. But as the world gets hotter, ice melts, revealing the darker-coloured land or water below. The result is that more of the sun's energy is absorbed, leading to more warming, which in turn leads to more ice melting – and so on.").

90 *See* discussion *supra* Part II.

91 The IPCC's Fourth Assessment based its projections on an estimated two mm annual rise in sea level, but new satellite data indicates that sea levels are actually rising at a rate of 3.2 mm per year. The IPCC's Fifth Assessment also reports that the rate of sea level rise is higher today than in previous decades. IPCC, *supra* note 87, at SPM-6. *See also* Stefan Rahmstorf et al., *Comparing Climate Projections to Observations up to 2011*, ENVTL. RES. LETTERS 7 (2012), *available at* http://iopscience.iop.org/1748-9326/7/4/044035/pdf/1748-9326_7_4_044035.pdf.

92 *See* Press Release, U.S. Geological Survey, *Sea Level Rise Accelerating in U.S. Atlantic Coast*, June 26, 2012, http://www.usgs.gov/newsroom/article.asp?ID=3256&from=rss_home#.UKkwqTnN4to (last visited Feb. 15, 2014) (reporting sea level rates increasing three-to-four times faster along portions of the U.S. Atlantic Coast than globally, according to a new U.S. Geological Survey report published in Nature Climate Change).

93 See *id.*

94 *Id.*

precautionary measures, especially in areas of the globe where sea levels are rising more slowly or more quickly than the global average rate.[95] In order to account for uncertainty, reference points for sea level rise should be based on the global average, measured according to a pre-determined methodology. The University of Colorado Sea Level Research Group uses satellite radar altimeters to measure global mean sea level and calibrates these satellite measurements with a network of tidal gauges.[96] These satellite altimeters—the TOPEX/Poseidon and Jason-1—"have produced high quality measurements of near global (66°S to 66°N) sea level from 1993."[97] Calibrated satellite measurements thus appear to be the most accurate data for determining whether sea level rise has reached an established mitigation reference point.

3. Natural Impacts

Precautionary reference points could be based on more localized natural occurrences that result from global temperature increases.[98] Ice sheet melt, loss of forest cover resulting from wildfires or insect-related tree die off, permafrost thaw, ocean acidification, or desertification are some examples of natural occurrences that are influenced by climate change and have the potential to act as positive feedback mechanisms.[99] Reference points based on any of these events would have to account for scientific uncertainty in both cause and effect associated with these phenomena. These precautionary reference points may particularly benefit from a scientific certainty threshold,[100] where precautionary measures are triggered unless Parties can provide sufficient evidence to demonstrate that the reference point exceedance will not negatively impact the global climate.

95 *See generally* Univ. of Colorado Sea Level Research Group, *Global Mean Sea Level*, sealevel.colorado.edu (last visited Feb. 22, 2014) (providing scientific measurement of global mean sea level).

96 *Id.* (Measurements from the TOPEX and Jason series of satellite radar altimeters have allowed estimates of global mean sea levels.).

97 John A. Church & Neil J. White, *A 20th Century Acceleration in Global Sea-Level Rise,* 33 GEOPHYSICAL RES. LETTERS L01602 (2006), *available at* http://naturescapebroward.com/NaturalResources/ClimateChange/Documents/GRL_Church_White_2006_024826.pdf.

98 *See* Kutil, *supra* note 53, at 260 (describing fisheries populations as a precautionary reference point for localized effects of climate change).

99 NRC, CLIMATE STABILIZATION TARGETS, *supra* note 74, at 29–46.

100 Sarah M. Kutil used the term "scientific uncertainty threshold" to explain the North Pacific Fishery Management Council's decision to close 150,000 square nautical miles to commercial fishing due to "overwhelming uncertainty in data." Kutil, *supra* note 53, at 234. According to Kutil, "NPFMC's decision to use its discretionary authority to close the Arctic Management Area implies a scientific certainty threshold that scientific data must satisfy before exploitation of a stock can occur." *Id.* at 237. While most precautionary reference points in the fisheries context trigger mandatory action when available data shows the reference point has been exceeded, a scientific certainty threshold would trigger mandatory action when there is no available data to show that the reference point has not been exceeded. Kutil argues that scientific uncertainty should trigger fisheries closures until data shows that fish stocks have reached predetermined threshold levels. *Id.* at 238.

4. Human Actions and Inactions

Mitigation reference points could also be based on human actions.[101] For example, failure to meet emissions reduction targets or a significant increase in deforestation could trigger mandatory precautionary action. Reference point triggers based on national actions could face resistance from the international community, which would be required to implement potentially expensive mitigation measures in response to actions of a single nation. These reference points could also be controversial because they implicate the ongoing debate over the nature of developed and developing country obligations, with developing countries insisting that their obligations be voluntary and developed country obligations be mandatory.

B. Positive Feedback Mechanisms

In the climate change context, positive feedback mechanisms are events that occur as a result of climate change and that accelerate the rise in temperature.[102] Some positive feedbacks have been identified and observed by the scientific community: for example, warming temperatures melt light-reflecting sea ice, and the resulting darker-colored water absorbs more sunlight than the lighter-colored ice, leading to an increase in temperature rise.[103] Other feedback mechanisms, such as methane releases from thawing permafrost, are difficult to measure, and thus less understood.[104] Positive feedback mechanisms in general are complex occurrences that contribute to the uncertainties associated with climate change projections.[105] However, because these mechanisms accelerate the rate of global warming, it is essential that they are accounted for in future climate change agreements.[106] The most effective mitigation reference points will reflect and account for accelerated warming resulting from positive feedbacks. This section provides a brief overview of some positive feedback mechanisms that should be accounted for when setting mitigation reference points.

101 *See* J.B. Ruhl & James Salzman, *Gaming the Past: The Theory and Practice of Historic Baselines in the Administrative State*, 64 VAND. L. REV. 1, 14–15, 48–49 (2011) (discussing human-action reference points in climate change and other environmental regulatory regimes).

102 Climate Change Feedback Loops, *supra* note 75.

103 *Id.*

104 *Id.*

105 *Id.*

106 *See* Jonathan M. Harris & Brian Roach, THE ECONOMICS OF GLOBAL CLIMATE CHANGE, 11, 20, 33–34 *available at* http://www.ase.tufts.edu/gdae/education_materials/modules/The_Economics_of_Global_Climate_Change.pdf (describing the unpredictable nature of feedback loops and the important role they play in economic analysis of climate change).

1. Sea Level Rise and Melting Ice

In 2007, the IPCC projected a rise in sea level between eighteen and fifty-nine centimeters (eight and twenty-four inches) by 2100,[107] although it cautioned that its projections "do not include uncertainties in climate-carbon cycle feedbacks" due to the limited understanding of some drivers of sea level rise.[108] In 2013, the IPCC predicted that the sea level likely would rise between twenty-six and eighty-five centimeters by 2100 from 2005 levels, also noting that the rate of sea level rise was increasing.[109] Some models have indicated that sea level could rise by up to 1.6 meters by 2100 if temperatures increase more than 3ºC.[110] Accounting for uncertainties in sea level rise is critical because a sea level rise of 0.5 meters could impact between five and two hundred million people each year and permanently displace more than four million people.[111]

Sea level rise is caused primarily by melting polar ice sheets, but there is uncertainty over the rate of melting.[112] If the Greenland and West Antarctica ice sheets were to melt completely, sea levels would rise by nearly forty feet.[113] Many scientists are concerned that these ice sheets are melting at a faster rate than previously projected.[114] In July 2012, an iceberg twice the size of Manhattan broke off a Greenland glacier, and scientists are concerned that the Greenland ice sheet "is thinning extensively amid warm temperatures."[115]

Melting ice also accelerates global warming due to the positive ice-albedo feedback effect: ice has a higher albedo (i.e., it is more reflective) than land or water.[116] Consequently, when exposed land or seawater replaces ice, more solar radiation is absorbed rather than reflected back into space.[117] Some potential mitigation reference points may account for this feedback better than others; for example, a sea level rise reference point would inherently include melting sea ice, but an atmospheric CO_2 reference point could fail to account for positive feedback resulting from melting ice.

107 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT 45 (2007).

108 *Id.*

109 IPCC, *supra* note 87, at SPM-6, SPM-18.

110 NRC, CLIMATE STABILIZATION TARGETS, *supra* note 74, at 37.

111 NRC, CLIMATE STABILIZATION TARGETS, *supra* note 74, at 43; The Geological Soc'y of Am., *Why Seas Are Rising Ahead of Predictions, GSA Annual Meeting Presentation: Could Estimates of the Rate of Future Sea-Level Rise Be Too Low?*, Nov. 1, 2012, http://www.geosociety.org/news/pr/12-82.htm (last visited Feb. 22, 2014) (providing an explanation of why positive feedbacks cause such great uncertanties in estimates of sea level rise).

112 NRC, CLIMATE STABILIZATION TARGETS, *supra* note 74, at 36–37.

113 H.R. REP. NO. 111-137, pt. 1, at 305 (2009).

114 *Id.* at 306 (finding that "scientists do not fully understand the dynamics of ice sheet melting," and that this is a source of increasing concern among the scientific community).

115 *Iceberg Breaks Off From Greenland's Petermann Glacier,* BBC NEWS, July 19, 2012, http://www.bbc.co.uk/news/world-europe-18896770 (last visited Feb. 22, 2014).

116 Nat'l Oceanic & Atmospheric Admin., *What Are Positive Feedbacks?*, http://www.ncdc.noaa.gov/paleo/abrupt/story2.html (last visited Feb. 22, 2014).

117 *Id.*

2. Permafrost Thaw

Permafrost is thawing at accelerated rates throughout the northern latitudes, which is particularly alarming because permafrost is a large GHG sink; some studies have estimated permafrost to contain between 7.5 and 400 GtC of methane alone[118] and another 1700 Gt of carbon.[119] A recent study has warned that the amount of carbon released from thawing permafrost will be 1.7 to 5.2 times greater than previous modeling studies have reported.[120] UNEP has reported that "[t]hawing permafrost could emit forty-three to 135 Gt of CO_2 equivalent by 2100 and 246 to 415 Gt of CO_2 equivalent by 2200."[121] Any of these estimates leave a much smaller slice of the atmospheric pie for anthropogenic emissions.[122]

Because permafrost releases GHGs other than CO_2 (principally methane), an atmospheric CO_2 reference point would not entirely account for additional emissions resulting from this feedback mechanism.[123] A sea level rise reference point may reflect these emissions more accurately, because ice melt is directly correlated with temperature increases.[124] As an alternative, a mitigation reference point could be established for methane and all other atmospheric GHG concentrations (measured as CO_2eq), which would take permafrost emissions into account, especially if methane measurements from one of the arctic sampling stations were used to determine when the triggering threshold is reached.

3. Forest Loss

In 2009, deforestation and forest degradation accounted for 20–25% of global anthropogenic GHG emissions.[125] Climate change is "increasing the

118 NRC, CLIMATE STABILIZATION TARGETS, *supra* note 74, at 222–25.

119 U.N. ENV'T PROGRAMME, POLICY IMPLICATIONS OF WARMING PERMAFROST iv (2012), *available at* http://www.unep.org/pdf/permafrost.pdf.

120 Edward A. G. Shuur et al., *Climate Change: High Risk of Permafrost Thaw*, 480 NATURE 32, 32–33 (2011). *See also Abrupt Permafrost Thaw Increases Climate Threat, Experts Say*, http://www.sciencedaily.com/releases/2011/11/111130161535.htm (last visited Feb. 22, 2014).

121 U.N. ENV'T PROGRAMME, *supra* note 119, at iv, 19 tbl.2.

122 *Id.* at 19.

123 *Id.* at 18.

124 NRC, CLIMATE STABILIZATION TARGETS, *supra* note 74.

125 H.R. REP. NO. 111-137, at 310 (2009). The precise contribution of deforestation and forest degradation to climate change remains subject to discussion. The IPCC estimated that land use activities, exclusive of agriculture, accounted for 17.4% of all greenhouse gas emissions in 2004, primarily from deforestation and forest degradation. T. BARKER ET AL., CONTRIBUTION OF WORKING GROUP III TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 27, 29 (2007), *available at* http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm. Later studies indicate that deforestation and forest degradation may contribute less, around 12% of total greenhouse gas emissions, but this may reflect increased fossil fuel combustion as much as lower actual rates of deforestation and forest degradation. G. R. van der Werf et al., *CO_2 Emissions from Forest Loss*, 2 NATURE GEOSCIENCE 737, 737 (2009). *See also* Yude Pan et al., *A Large and Persistent Carbon Sink in the World's Forests*, 333 SCIENCE 988, 988–93 (2011) (discussing the significance and uncertainty surrounding the precise measurement of carbon

frequency and intensity of wildfires,"[126] which also results in increased carbon emissions.[127] According to the National Research Council, each degree Celsius increase will double to quadruple the area burned by wildfires in western North America.[128]

Forests are also being killed off as a result of increased insect infestations.[129] The warming climate and subsequent reduction in freezing temperatures have led to an explosion in mountain pine beetle populations, which have decimated large areas of forest in North America.[130] "Beetles are now emerging in mid-May, rather than late July, and the length of the flying season is allowing multiple generations to emerge in the same year; second generations have been observed emerging in August and September."[131] The effects on Canadian forests and CO_2 emissions have been devastating.[132] By the end of 2006, the mountain pine beetle had killed 130,000 square kilometers of forest in western Canada.[133] Scientists estimate the cumulative impact of the mountain pine beetle outbreak during 2000 to 2020 to be 270 MtC on average over 374,000 km^2 of forest.[134]

In other parts of the world, an increase in forest cover may actually be contributing to an increase in warming.[135] For example, more than 100,000 square kilometers of Eurasian tundra have become forested as temperatures have increased over the past fifty years.[136] Whereas snow-covered tundra reflects sunlight, darker-colored foliage absorbs sunlight, resulting in increased warming over time.[137]

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sequestration from forest ecosystems). Regardless of its precise contribution, deforestation remains the second largest anthropogenic source of carbon dioxide to the atmosphere, after fossil fuel combustion.

126 H.R. REP. NO. 111-137, at 311 (2009).

127 *Id.*

128 NRC, CLIMATE STABILIZATION TARGETS, *supra* note 74, at 7.

129 U.S. EPA, *Climate Impacts of Forests*, http://www.epa.gov/climatechange/impacts-adaptation/forests.html (last visited Feb. 22, 2014).

130 *Id.*

131 Mark Squillace & Alexander Hood, *NEPA, Climate Change, and Public Lands Decision Making*, 42 ENVTL. L. 469, 494–95 (2012), (citing Jeffrey B. Mitton & Scott M. Ferrenberg, *Mountain Pine Beetle Develops an Unprecedented Summer Generation in Response to Climate Warming*, THE AMERICAN NATURALIST, May 2012, at E163, E166 tbl.2).

132 *See generally* Mitton, *supra* note 131, at 1 (chronicling the pine beetle's devastating effects in Western North America).

133 W.A. Kurz et al., *Mountain Pine Beetle and Forest Carbon Feedback to Climate Change*, 452 NATURE 987, 987 (2008).

134 *Id.* at 987. To put this in perspective, the maximum annual beetle impact (20 MtC per year for the scientists' relatively small study area) is nearly equal to direct forest fire emissions of 27 MtC per year for all of Canada from 1959–1999. As another comparison, the net greenhouse gas emissions over 21 years of 990 $MtCO_2eq$ from one insect outbreak is equivalent to about five years of emissions of 200 $MtCO_2eq$ from Canada's transportation sector (based on emissions in 2005). *Id.* at 987, 989.

135 *See generally* Marc Macias-Fauria et al., *Eurasian Arctic Greening Reveals Teleconnections and the Potential for Structurally Novel Systems*, 2 NAT. CLIMATE CHANGE 613, 615 (2012) (last visited Feb. 22, 2014) (discussing the difficulties in predicting the growth and spread of wildfires).

136 *Id.* at 613.

137 *Id.*

Future climate change-induced forest losses are difficult to estimate, in part because natural events such as wildfires and droughts are typically sporadic and difficult to predict.[138] Moreover, increases in CO_2 levels may actually lead to increased forest productivity in some areas, while contributing to reductions in productivity in other areas.[139] Emissions increases due to forest loss are therefore difficult to account for through mitigation reference points. An atmospheric concentration reference point would account for CO_2 emissions from forests, but reductions in sequestration capacity would not.[140] A reference point based on forest loss could be established to account for both increased emissions and reductions in sequestration rates, and could also be addressed through responsive mitigation actions, such as increased reforestation activity.

V. PREDETERMINED ACTION WHEN MITIGATION REFERENCE POINTS ARE REACHED

When a mitigation reference point is reached or exceeded, it would automatically trigger a mandate for Parties to implement pre-determined mitigation action. Predetermined mitigation action can take a variety of forms in the climate change context, as long as the overarching objective is to reduce GHG emissions or atmospheric GHG concentrations.[141] According to UNEP, global GHG emissions could be substantially reduced by 2020 through improved energy efficiency, implementation of a low-emission energy mix, and reductions in non-CO_2 GHG emissions.[142] The following examples include potential pre-determined mitigation actions that could be implemented alone or in combination with other measures:

- *Mandate use of renewable energy technologies.* If 38% of global electricity (4,000 TWH) was produced using renewable energy technologies, emissions could be reduced by 1.5 to 2.5 $GtCO_2eq$/year.[143]

- *Prohibit the construction of coal-fired power plants.* If all new power plants were built to use natural gas, emissions would be reduced by 1.9 $GtCO_2e$/year.[144]

- *Require energy efficiency improvements or fuel switching.* Emissions can be reduced in the industrial sector in a number of ways, including

138 Caroline Perry, *Wildfires Projected to Worsen with Climate Change*, HARVARD GAZETTE, Aug. 28, 2013, http://news.harvard.edu/gazette/story/2013/08/wildfires-projected-to-worsen-with-climate-change/ (last visited Feb. 26, 2014) (noting that "wildfires are very difficult to predict").

139 *See* UNEP, VITAL FOREST GRAPHICS 35 (2009), *available at* http://www.unep.org/vitalforest/Report/VFG_full_report.pdf.

140 Worldwide, vegetation and soils are estimated to sequester 2.6 gigatonnes of carbon a year. *Id.* at 36.

141 *See generally* United Nations Framework Convention on Climate Change, *supra* note 4, at 2, 4, 8, 10–11 (acknowledging the grave importance of reducing emissions and accepting a wide diversity of mitigation actions).

142 UNEP, BRIDGING THE GAP, *supra* note 69, at 28.

143 *Id.* at 33.

144 *Id.*

improved energy efficiency, fuel switching, power recovery through cogeneration, and product substitution. The estimated emission reduction potential ranges from 1.5 to 4.6 $GtCO_2e$/year.[145]

- *Require increases in fuel efficiency standards.* Recent vehicle fuel efficiency standards adopted in the United States, European Union, and China will reduce GHG emissions by 0.3 $GtCO_2e$/year by 2020.[146] According to projections by the International Council on Clean Transportation, increased use of biofuels and improvements in vehicle efficiency could reduce global GHG emissions by 1.7 $GtCO_2e$/year.[147]

- *Require new building codes.* High efficiency building design can greatly reduce electricity consumption, and energy-plus or net energy supplying buildings actually produce more energy than they consume. The Fourth Assessment Report of the IPCC projected that increased efficiency in the buildings sector had the potential to decrease emissions by 4 $GtCO_2e$/year, but UNEP's analysis concluded that reductions of 1.4 to 2.9 $GtCO_2e$/year are likely more realistic.[148]

- *Require changes in forest management or decreases in deforestation rates.* Many mitigation options are available in the forestry sector, including reduced emissions from deforestation and degradation, enhanced carbon sequestration through afforestation or agroforestry, and sustainable forest management. One study reviewed by UNEP estimated that emissions could be reduced through the forestry sector by up to 8.5 $GtCO_2e$/year.[149]

- *Require improvements in land use practices.* Emissions could be reduced in the agricultural sector through adjustments in cropland and livestock management practices by 1.1 to 4.3 $GtCO_2e$/year.[150]

- *Require reductions in methane emissions.* Methane emissions from landfills can be reduced through landfill gas utilization and solid waste management by a projected 0.8 $GtCO_2e$/year.[151]

The above actions could potentially be attained by the year 2020, considering current rates of technological advancement.[152] Moreover, these examples are only a sampling of potential measures that could be implemented under a mitigation reference point system.[153] Specific measures could be required in response to reference point triggers, or Parties could be afforded some flexibility in choosing which measures to implement. In either

145 *Id.* at 34.
146 *Id.* at 35.
147 *Id.*
148 UNEP, BRIDGING THE GAP, *supra* note 69, at 36.
149 *Id.* at 37.
150 *Id.* at 10.
151 *Id.* at 37–38.
152 *See id.* at 10.
153 *See id.*

event, all Parties should not be required to implement all mitigation measures on an equal scale, taking into account national circumstances and capabilities.

In order to take the national circumstances of individual Parties into account, while also ensuring that adequate mitigation actions are implemented on a global scale, two categories of mitigation actions could be established: global actions and country-specific actions. Global mitigation actions would be mandatory for all Parties, while country-specific mitigation actions would be tailored according to Parties' past and present emission rates and mitigation capacities. For example, a global mitigation mandate could require all Parties to reduce emissions by a predetermined percentage, such as 5%. Country-specific mitigation mandates would vary from Party to Party, and should be proportionate to each Party's emissions and emission reduction commitments. Thus, if a 415 ppm reference point is exceeded, a country like the United States would be required to implement additional mitigation actions, such as increasing renewable energy generation capacity by 5%, in addition to meeting the 5% global emissions reduction mandate. A least developed country like Ethiopia would not be required to do anything. Ideally, Parties should propose their own specific mitigation activities to ensure that they have the capacity and willingness to implement such mitigation actions. However, it is essential that mandatory mitigation actions are determined at the time that mitigation reference points are established; if a Party fails to propose sufficient response actions, quantifiable emissions reductions should be imposed as a default mitigation response.

In addition, a predetermined mitigation action should be proportionate to its corresponding reference point. For example, if a reference point is based on increased emissions from forest loss due to wildfire or tree die-off, a proportional response measure could be to engage in reforestation or afforestation in order to offset the emissions increases. Offsets could be required at 2:1 or 3:1 ratios in order to account for future forest losses. On the other hand, if a reference point is based on atmospheric CO_2 concentrations exceeding 415 ppm by 2025, and concentrations hit 425 ppm in 2020, then stringent emissions reduction measures should be triggered.

Ideal pre-determined mitigation action will achieve immediate, long-lasting reductions in emissions. Actions that achieve temporary emissions reductions should only be required if long-term reductions cannot be implemented. Predetermined mitigation actions do not have to be limited to national emissions reductions; technology transfer and sustainable development funding can be as equally effective in reducing emissions, and may be easier to implement in some cases.[154] Measures that promote sustainable development should be favored over measures that do not. However, it is imperative that mitigation actions actually result in either a measurable decrease in GHG emissions or a measurable increase in

154 *See generally* United Nations Framework Convention on Climate Change, *supra* note 4, at 18, 24, 58, 63. (highlighting the importance of funding and technology transfer as well as emission reductions).

sequestration capacity in order for precautionary mitigation reference points to be effective.

VI. CONCLUSION

Mitigation reference points have the potential to increase ambition to reduce greenhouse gas emissions because they would impose mandatory mitigation requirements on Parties when predetermined thresholds are reached or exceeded. To be successful, both mitigation reference points and corresponding mitigation actions must be predetermined. Furthermore, the response must be mandatory and enforceable through an internationally agreed compliance mechanism to hold Parties accountable for failing to take mitigation action. Mitigation reference points must account for scientific uncertainty regarding both the causes and effects associated with climate change; effective reference points will account for emissions resulting from positive feedback mechanisms, in addition to anthropogenic emissions. The primary objective of any predetermined mitigation action must be to reduce anthropogenic GHG emissions or atmospheric GHG concentrations. Perhaps most importantly, all Parties must generally understand mitigation reference points and mandatory mitigation actions, and Parties must understand their individual obligations under the program. Lack of understanding must not be an excuse for failure to act.

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