Proceedings - SRRR Web Workshop:
EPA Climate Change Indicators
September 28, 2021

Link to the Video of the Web Workshop
https://www.youtube.com/watch?v=GFkdqBKmocc

https://sustainableroundtable.org

http://www.epa.gov/climate-indicators

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Overview of EPA's Climate Indicators

September 28, 2021

Sustainable and Resilient Resources Roundtable Workshop

Mike Kolian, Environmental Scientist, Project Lead, EPA Climate Change Indicators**:**

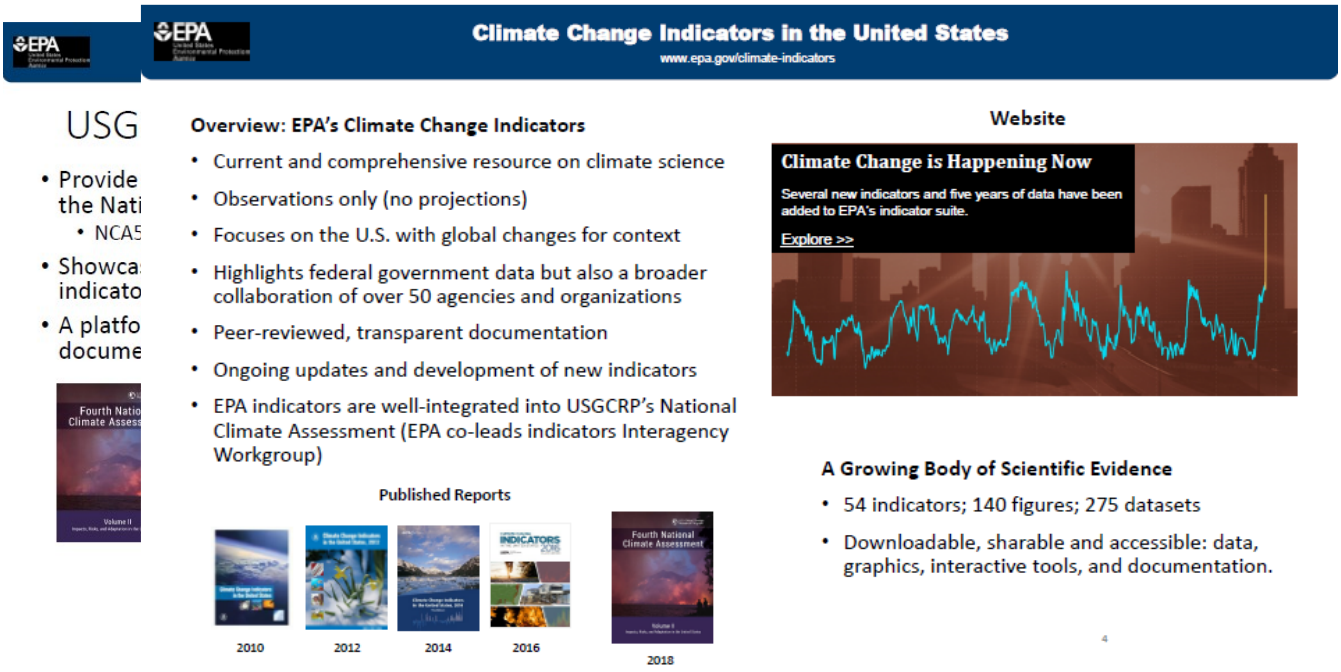
We updated all of the Climate Change Indicators and the website in May, for the first time since the new administration took office. There was an eagerness to look at the data, and see what we see, in terms of observations related to climate.

Today we're going to go through several indicators, so you have a sense of the breadth of the project, and the number of indicators we have. Indicators are important assets for understanding changes related to climate. They reveal multiple lines of evidence that things are happening now. This isn't for the future. In fact, we're setting climate records all the time. Most observations in the 21st century are above the historical baseline, on a consistent basis. What once were rare events are now common, due to a warming climate. It allows for the routine tracking of the latest science. It allows us to stay on top of the most recent research, add additional years of data, and add additional metrics to the suite.

Importance of Indicators

- Indicators provide multiple lines of evidence that climate change is occurring now and here in the U.S., affecting public health and the environment.
- Allows for routine tracking of observed changes and the latest science and data.
- Indicator and data are relevant at national, regional, state and community levels in U.S.
- Climate indicators facilitate examination of risk, exposure and vulnerability, and Environmental Justice considerations.

The EPA Indicators Tracking System is very functional, and allows us to track these things over time. There are indicators at many different scales, national, regional, state community levels. This allows for exploration into these changes in different contexts, for different decision making purposes.



We're now looking forward to thinking about how we examine risk a little more closely, and exposure, and vulnerability. And we'll get into a little bit of, towards the end, of how we're doing that, and going to that next level, and even environmental justice considerations, with respect to those same vulnerabilities in the specific sensitive population groups most affected by climate.

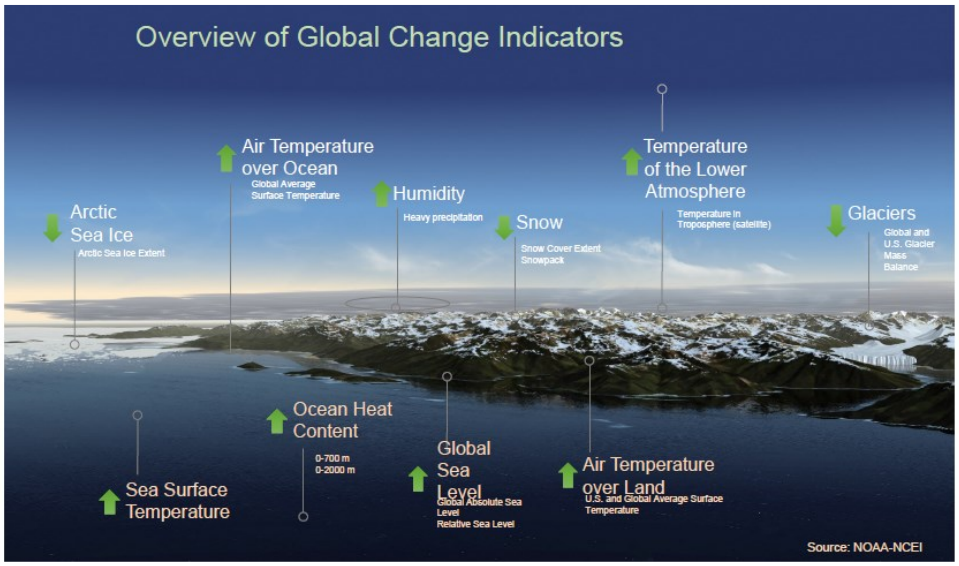
So, just a real quick snapshot of the resource itself. It's very current. As I said in May, we updated everything online, as much data as we could get into, the indicators at the time, and will continue to routinely update these going forward.

We are not looking at projections at all, so again, this is just observations. We are focused on the US. There's a lot of global changes for context, highlighting here that we do work with several members of the federal government and agencies, their longtime partners. But other agencies and organizations, academic researchers have helped us on the data contributions side, and furthering the research.

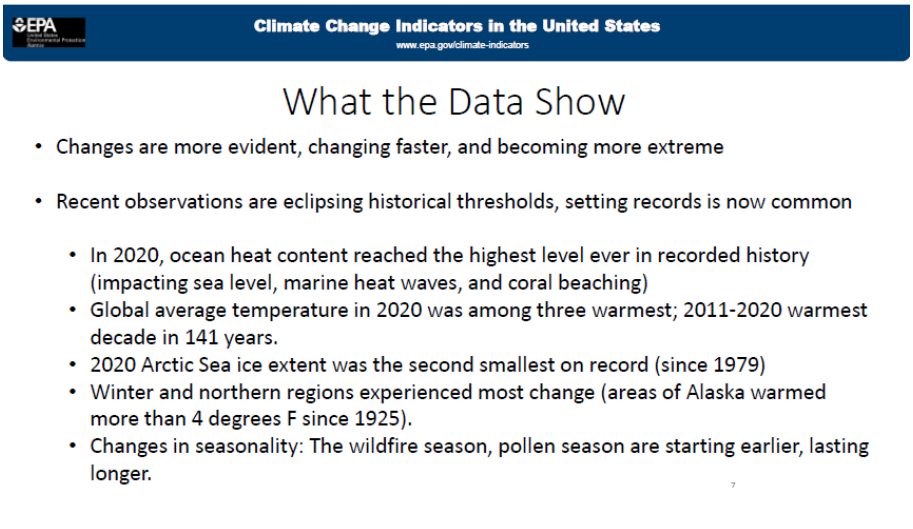
We have often looked to the peer review literature, to seek new indicators in new ways of doing some of these changes. So all of the information that we produce is peer reviewed. There is discretionary peer review on a published report that we may have, or any new indicator that's assembled.

There is quite extensive documentation behind the scenes, if you ever wanted to look at how something was put together. Ongoing updates, that's the real value of indicators, so we'll continue to do that. This is a sustained effort, and many of the indicators are integrated now, into USGCRP's National Climate Assessment. This is a periodic, the National Climate Assessment that comes out every four years or so, through our partnerships, and who we're working with there. That's become a foundational science input into that effort.

It's a growing body of evidence. There are over 50 indicators, several of these represented by individual figures. So many, many data sets are behind these things. We've made a concerted effort to make everything more downloadable, shareable, accessible. That is the other real true purpose of all of this is, is to make it accessible, and communicate these changes. Any additional ways we can do, to make that happen, we're trying to. There isn't a standing interagency working group that is focused on indicators, advancing the science, advancing the monitoring systems that agencies have, that produce the data that go into indicators, that the research that turns into indicators. We're working together to keep moving in that same direction, recognizing the agencies do a lot of observation and monitoring. They've invested a lot of resources. They (NASA-USGS) just launched [Landsat9 satellite]LINK. This is just a very high level, and again, our report and our work, isn't so much global, but just for context, and just to get everybody in the spirit of indicators, we look across all of these things. The arrows here are reflective of the preponderance of data.



So we know that air temperatures are increasing. We know snow cover, snowpack, we're seeing dramatic declines in the cryosphere and elsewhere. We know sea level is increasing, ocean heat content, increasing. All of these things are consistent with a warming world. All of these things we would want to be measuring and tracking, in terms of wanting to know what's happening to the climate. So these are all connected, air temperatures increase, land ice melts, and sea level rise increases. There is a reason to be looking at all of these things, but this is high level information. But what do we see with our indicators, and across the US?



In general, changes are more evident, changing faster, and becoming more extreme. We were able to kind of step back after this last update, and really examine what has been happening over the last four years. And sure enough, I mean, the 21st century is really at the edge of the distribution, in many cases.

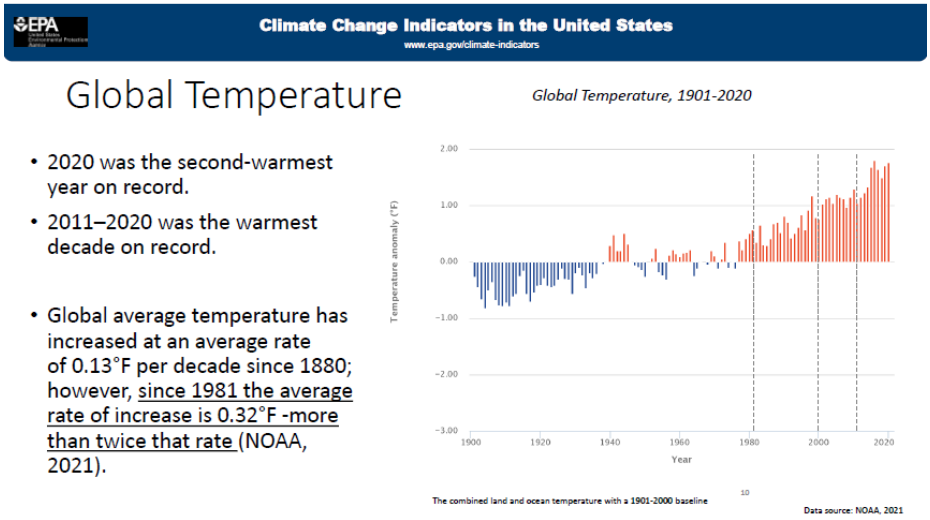
Not every indicator is setting records each year, but certainly, the temperatures, and some of the more extreme indicators that we have, are starting to do that. Setting records is now becoming a little bit more common.

In 2020, ocean heat content reached its highest level in recorded history. This has many, many impacts at sea level, marine heat waves. We're starting to see, with increasing frequency, coral bleaching. Global temperature in 2020, was among the warmest among the three. There's a little bit of debate, and it's real neck and neck, but the last decade was the warmest on record. And when we looked, glanced to the future, the next five years, within the next five years, there will be another global record set. So that is the way it's headed. Winter and northern regions are experiencing a lot of change, compared to elsewhere, and we have evidence of that we'll show.

Changes in seasonality is another interesting aspect to consider, and there's plenty of indicators that express these changes to seasonality. These are the various categories, or bins, chapters, if you will, that we put indicators in.

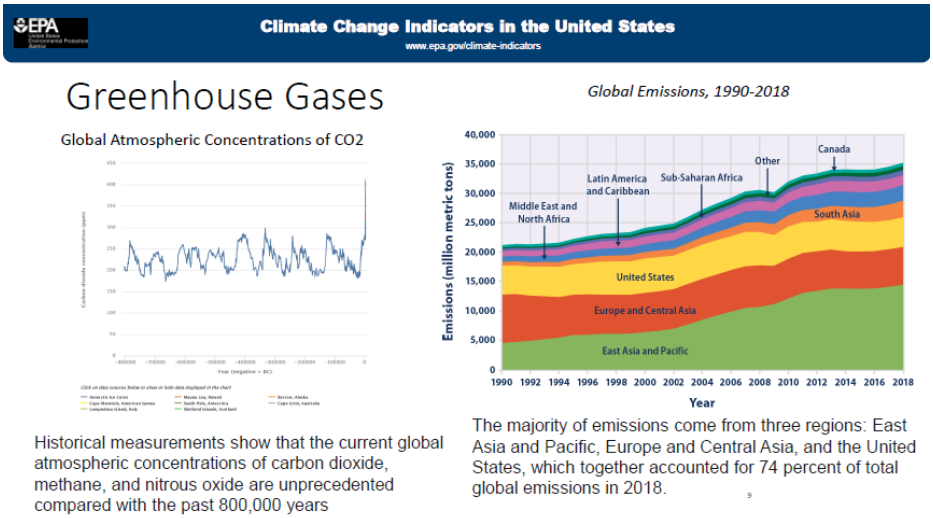
We just have a smattering of indicators across these, again, to give you a sense of what we have. Starting out the story, we have always done this with the premise that there are drivers, there is a human contribution here, driving these changes, and that is emissions of greenhouse gases.

So we have global concentrations of CO2 looking all the way back 800,000 years, where we have ice core data. We're really looking at the observational record over time and seeing how that's changed.



We examine the last 50, 60, 70 years of our greenhouse gases, and we're seeing a pretty steady rise, and in fact, even in some cases, increased rates of change. Even with the COVID outbreak, we saw quite a spike and jump in greenhouse gases, particularly CO2, which was a bit surprising, with some, some recent findings from NOAA.

Global emissions continue to rise, and you can see the players, the major countries and regions of the world that contribute to that. But this just sets the stage. Global temperature, classic measure, that that is captured in the suite of indicators, 2020, again, nearly the warmest year on record.



And you can see recent change. We looked from about 1980 to present, and it's all continuing to rise, decade after decade, year after year. This is where and what is contributing to some of those record breaking temperatures that we saw across the West this year, and elsewhere, 100 degrees in the Arctic in 2020, the first ever time that was recorded.

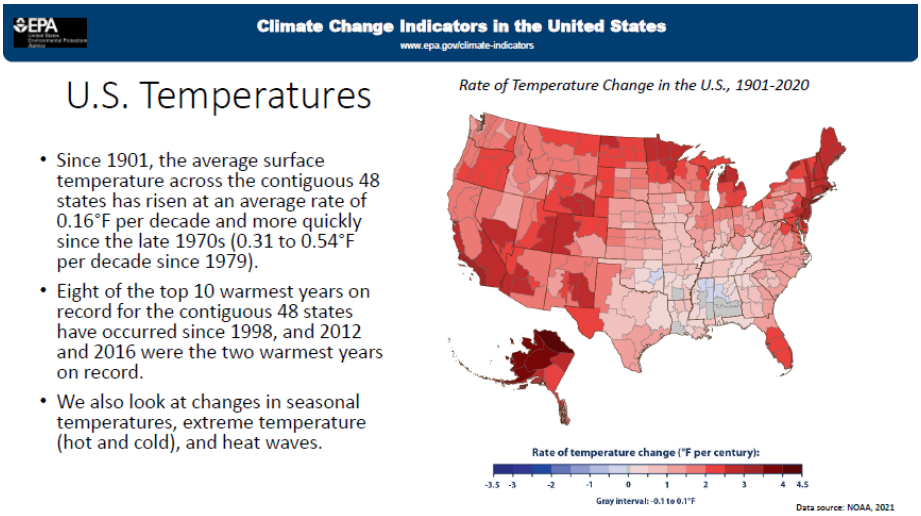
US temperatures. This is a really nice, complete data set from NOAA, that we get climate division data. This is a rate of change across the US over this. From 1900 to present.

There is generally positive temperature change, there are a few areas in the Southwest that haven't seen as much, or there's a little bit of cooling. This is a signature of the data set, and the temperature record for this region, due to other factors that are at play. Some of the deforestation, some of the land use change, and aerosols in the region have contributed to that.

But over time, as we have updated this map, those blues turned to grays, and the grays turned to red, and that slowly starts to disappear. But we have a really good context for the rate of change in the US. And we see Alaska, just to point out really quickly, is warming the fastest among many areas. So the Northern regions, the high latitude areas are warming at a faster rate than elsewhere. Changes in seasonality, and I'll just hit on this really briefly. There's some more down the line that are related to seasonality, but a couple from the snow and ice chapter, snowpack, it's a keystone indicator. It's a very important measure, especially in the spring transition time of year, how much snow do we have, that is a very predictable situation for how much water supply you'll have, later on down the line. Throughout the summer, it regulates stream flow, and it also primes conditions for wildfire or not.

So there is really a critical need for the snow that we do have, and we see, over the course of the year, this is tracked continuously over time, but this is showing in general at the majority of the sites, that April 1st timeframe, in which there's a lot of measurements, that snowpack is decreasing.

A very related measure is the timing of winter/spring runoff. This is a stream flow measure, and that is occurring earlier in the year, meaning less stream flow, down for later months of the year. That also has impacts very much related to changes in early season warming and temperature.



Alaska permafrost. This is a shot at long term measurements in borehole sites across the interior and northern regions of Alaska. This is measuring temperature, so this is deep underground, it's a really good indicator, it's out of the context of a lot of dynamic changes.

Long term measurements are showing an increase, particularly at the northern colder sites. And this is very consistent with some of those air temperature changes, very coincident and correlated to those air temperatures.

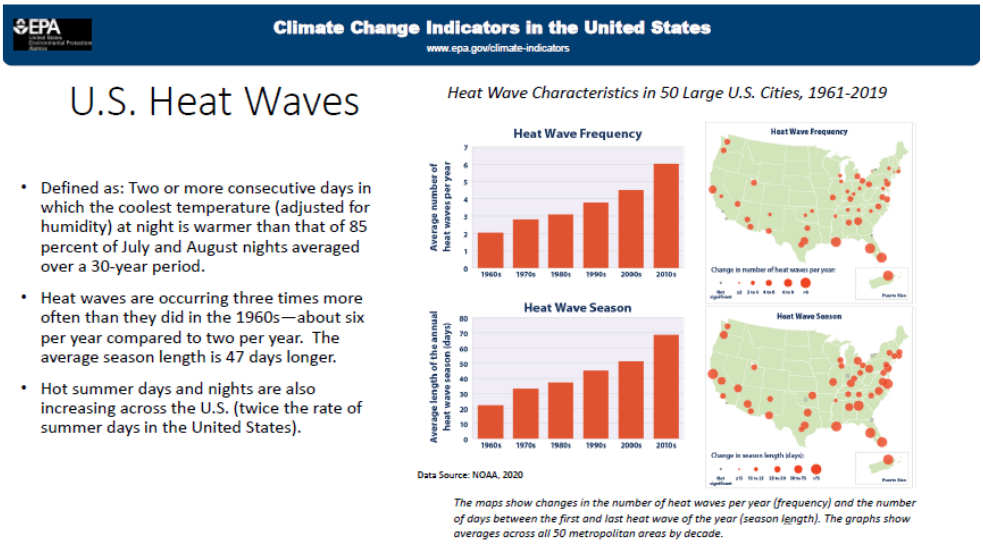
So we had this happening. There are impacts, of course, associated with permafrost, and some of the infrastructure, and other damages that can occur with thawing of permafrost, in addition to any greenhouse gas flux that may result.

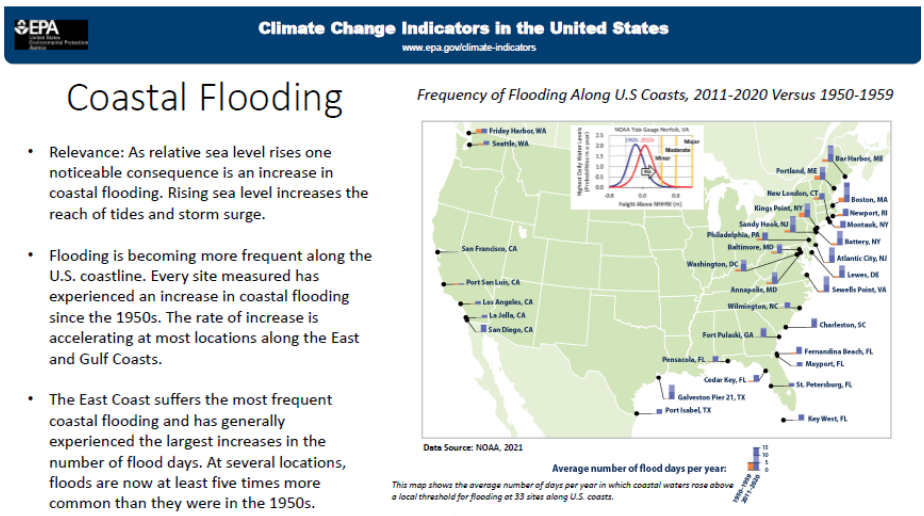
I think, at this point, I pause, and I'm going to hand it over to my colleague, Lisa Bacanskas, to keep rolling through some indicators.

Lisa Bacanskas, Environmental Scientist, EPA Climate Change Indicators

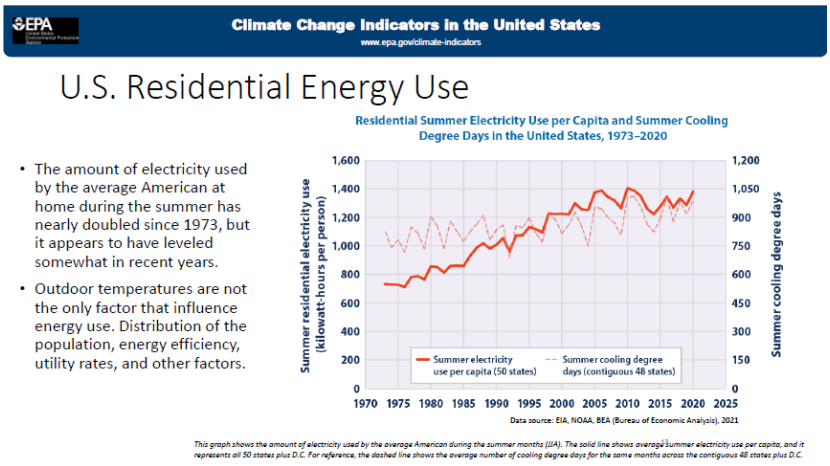
Here is a really relevant indicator, especially for this summer, where we've had many extreme heat wave events, it's the leading weather killer in the US, and it impacts the most vulnerable in our communities.

Here are a few figures that show the different characteristics of heat waves. So we're seeing how many occur every year, and the number of days between the first heat wave and last heat wave of the season. It looks at the 50 large cities in the US. Overall, we're seeing that heat waves are occurring three times more often than they did in the '60s. That's about six per year, as compared to two per year. And the season length is also getting much longer, about 47 days. We also have a high and low temperature indicator, and that shows that summer nights have warmed at nearly twice the rate of summer days in the US.

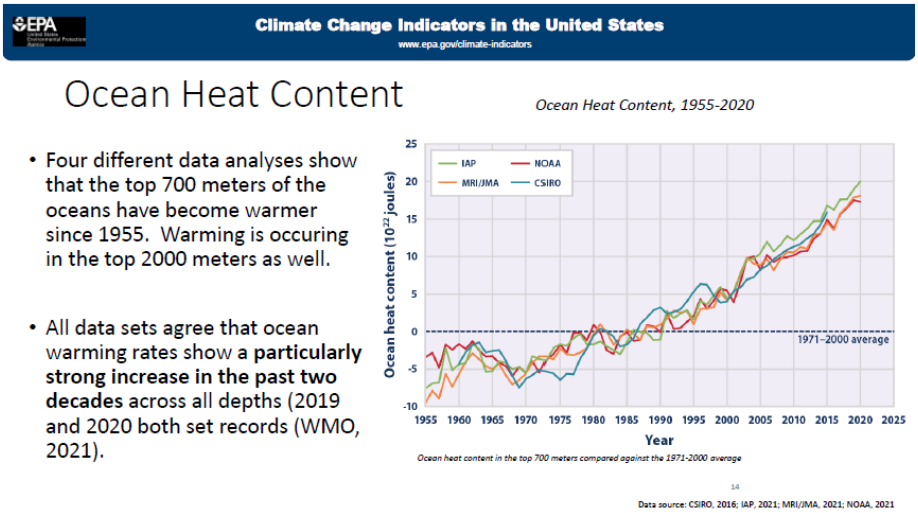




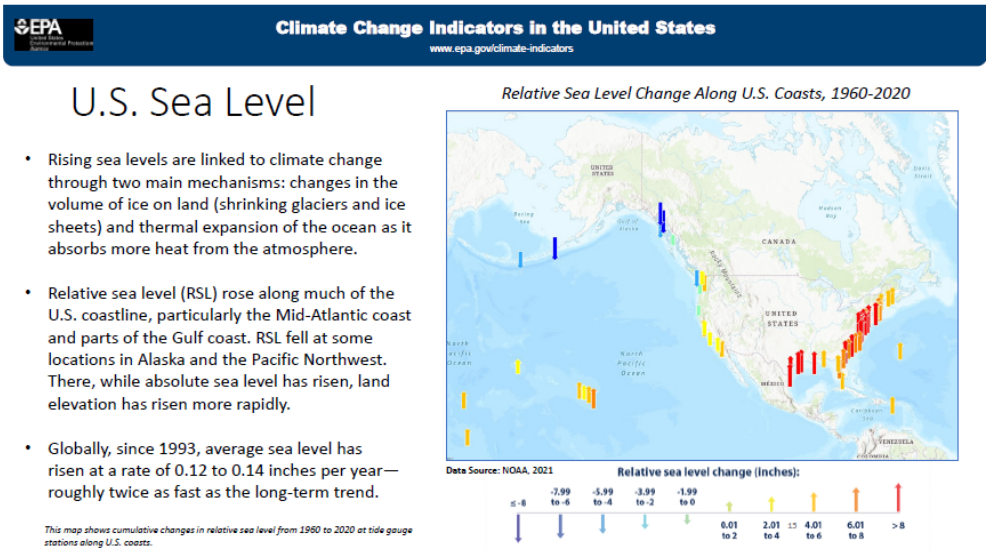
Moving on to air conditioning and US residential energy use, this is another one of our new indicators, and it's a different type of indicator, because it looks at a response to changes in temperature. So here we see trends related to cooling and heating in US homes. The dotted line in the figure shows the increase in cooling degree days, or the days that you might need to turn on your AC. And the solid line shows the amount of electricity used by homes in summer months, which has nearly doubled since 1973.



Next, we'll move on to an indicator that shows the trends in global ocean heat. the trends in global Ocean Heat Content, this is from 1955 to 2020. Data are available for the top 2000 meters of the ocean, and that accounts for nearly half of the total volume of the world's oceans. And you'll see here, the long-term trend is showing that oceans have become warmer since 1955, it also shows that the heat absorbed by surface waters extends to a much lower depth on over time, and that's especially in the last two decades. And that leads us into US Sea Level. So this map shows changes in Relative sea level, we also have Absolute sea level indicator that's not shown here, this looks at data from 1960 to 2020, it's called Relative because it reflects the changes in sea level, as well as vertical land movement or changes in elevation.



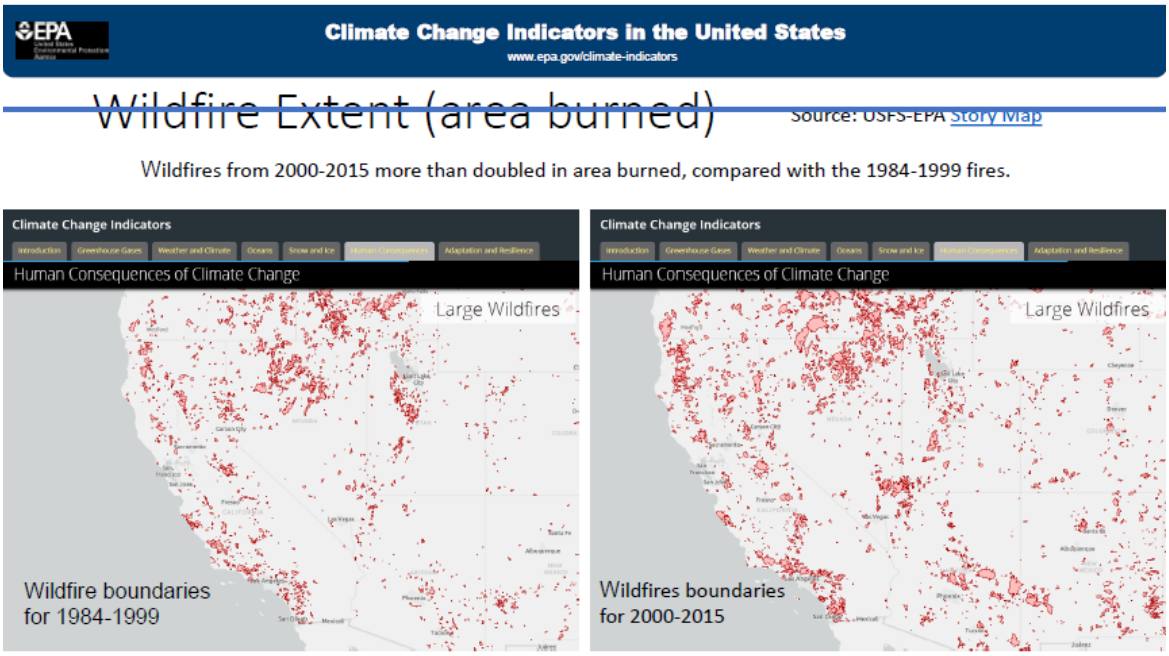
So as you can see from the figure, Relative sea level rose along much of the Coast in particular, where you see the clusters of red and orange and yellow arrows on the Mid-Atlantic and in the Gulf where some stations actually registered increases of more than eight inches of Relative sea level rise. Meanwhile, Relative sea level fell at some locations in Alaska and the Pacific Northwest, and that's due to land elevation rising more rapidly than the Absolute sea level.

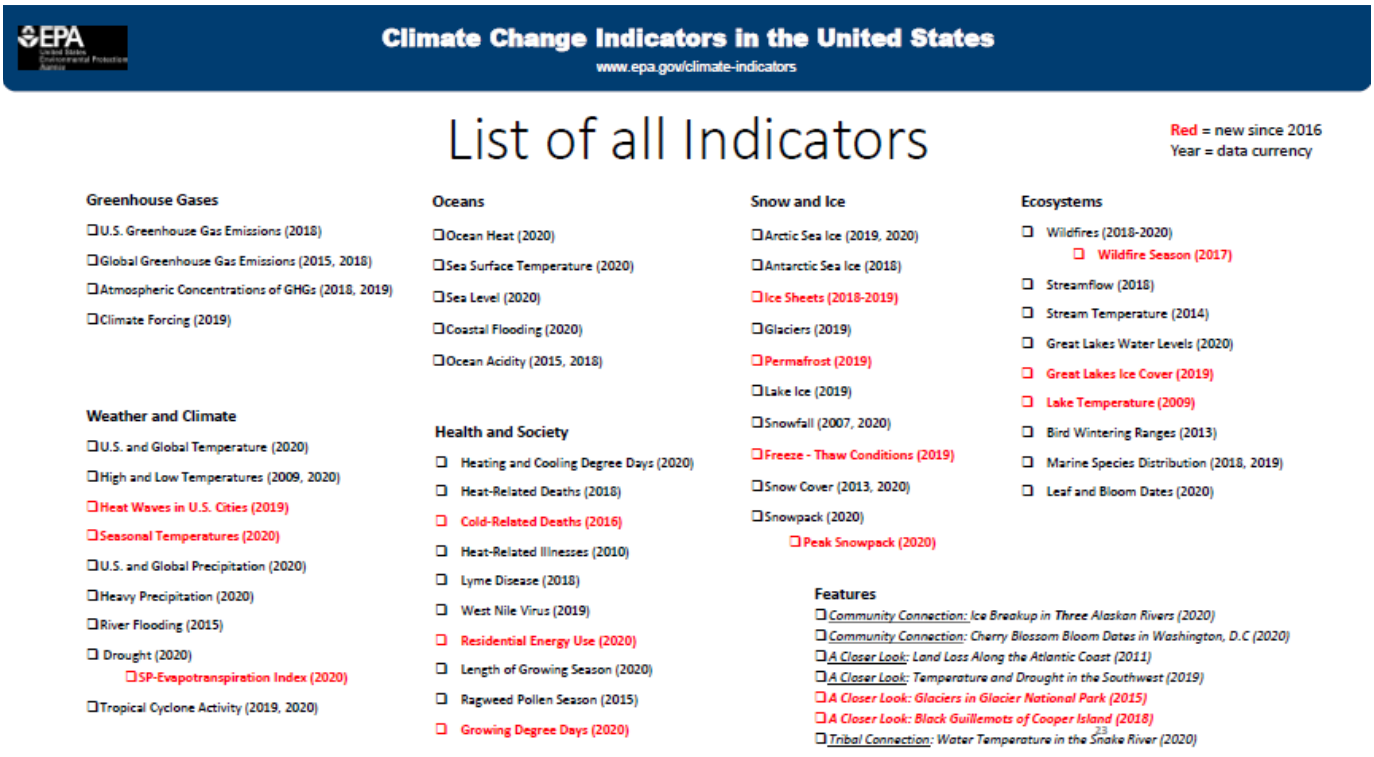


Moving on to Coastal flooding, so as sea level rises, of course, we also see an increase in Coastal flooding events, they typically occur during a seasonal high tides or during storms, but in recent years, we're increasingly seeing flooding on days with less extreme tides, and even the sunny day flooding.

Coastal flooding can lead to a variety of impacts, of course, we're all familiar with impacts on roads and road closures, drinking and wastewater, infrastructure failures, and health impacts that come from that. And so this map looks at tide gauge data at 33 sites across the US, shows how the frequency of Coastal flooding has changed over time, so each small bar graph compares the first decade of wide spread measurements, the 1950s in orange, and on the left with the most recent decade, which is shown in purple. So you can see from the map that every site has an increase in flooding since the 1950s, and it's especially evident on our East and Gulf Coasts.

Another indicator to walk through to give a flavor of what's in the suite, here is one of our wildfire indicators. Climate change has contributed to increased temperatures and drought, longer dry seasons, drier soils and vegetation, warmer springs, earlier melting of snow, all of these lead to higher risk for wildfires, especially in the West. This map, featured in a Story Map that's linked to our website, shows the wildfires area burned more than doubled compared from 1984 to 1999, compared with 2000 to 2015. You can check out our website, we have a number of other wildfire metrics in our indicators suite.



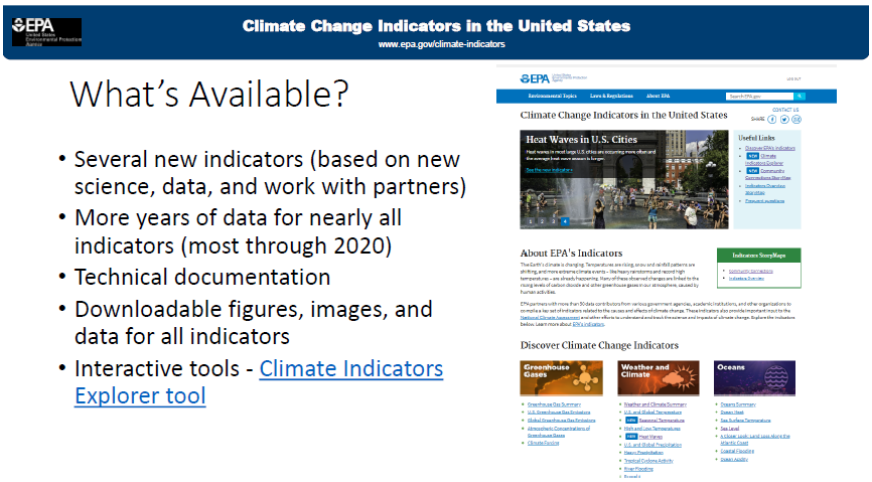


So this is a list of all of the indicators in our suite, there are multiple metrics under each that are

included within each of these indicators, the new ones are shown in red, and then in parentheses, you can see how current the data are in the indicator on the website. We also have a number of features that's in the lower right-hand part of the slide, those highlight either a specific region data record, or an area of interest. For example, we have a new feature that looks at glaciers in Glacier National Park. And so these indicators don't cover the full suite of climate impacts, and we are continually looking into adding to the suite.

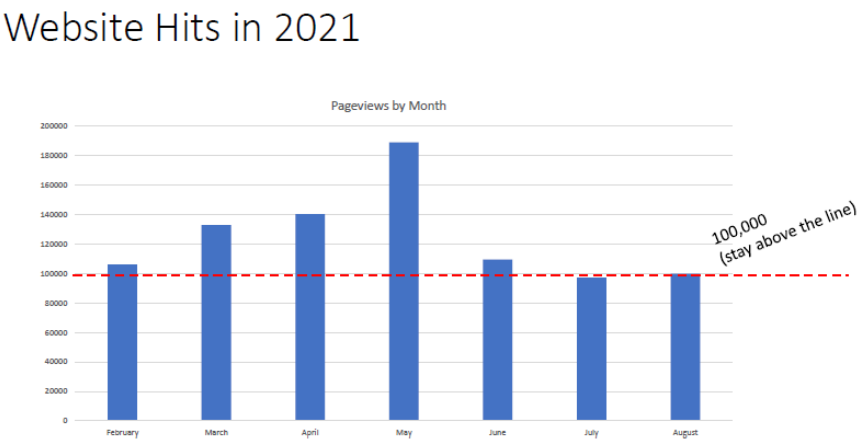
Lauren Gentile, Geographer, EPA Climate Change Indicators

We've run through the various indicators that we have. Again, we have many more than what you've seen, this is just a snapshot, but it gives you a good idea of the depth and breadth of our indicators.



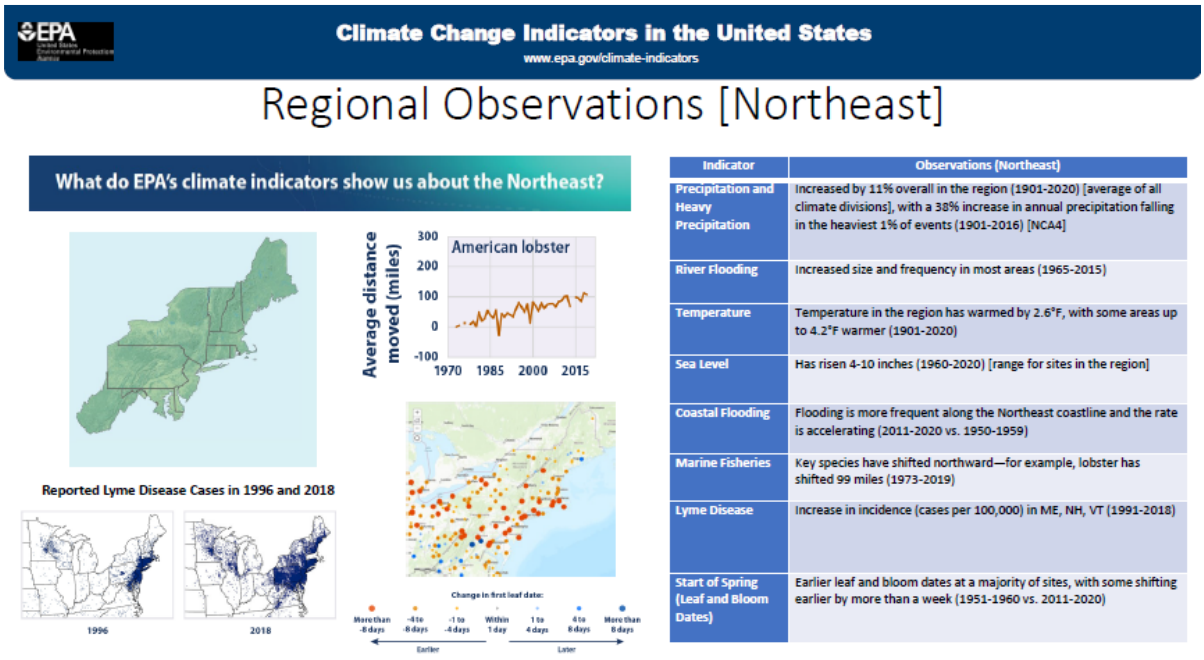
What does this mean in terms of communications? How can we best communicate the indicators, the various information, the data that's available, et cetera? Mike has already gone over most of this, but we do have a bunch of new indicators, as well as our original ones, and again, these are based on new science data that becomes available, and also the work with partners is extremely important. We also have data now for most of them through 2020, and we also have technical documentation for every one of our indicators. And again, that goes through a very substantial peer review process prior to publication and making it available. And all the indicators are made to be downloadable in terms of its figures, images, and the data itself, and we do have an organ to this, we are expanding into looking at developing new interactive tools, and everything again is available on our Climate Change Indicators website.

So this is a graph to show the Website Hits in 2021, just as a reminder, the last previous four years, we were unable to publicly update our indicators website, so that was a major push, this year was being able to do that, we had been updating our indicators in the background, but this was now the chance to update

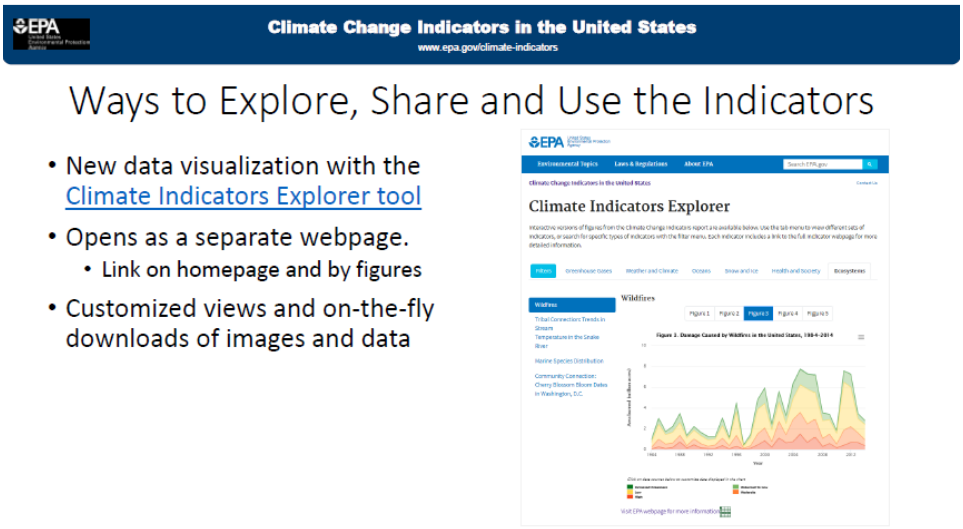


absolutely everything on our public facing website. And you can see that in May, when we released this and made everything public again, we had quite a nice spike to about, it looks like 180,000 views, if I'm reading that right, and it has dropped now and leveled off, and the goal really is to stay above 100,000 page views in a month, and so part of our new set of goals this year is to really start pushing and getting back into that communication mindset.

So we are looking to develop new and innovative indicator products to expand that outreach and communications, and to also be able to reach a wider range of audiences, and maybe even very specific audiences with specific interests, so tailoring things a bit more, and this could include new visualizations that summarize indicator data in new ways, and I'll go through those in the next slides, some examples of what those might be.

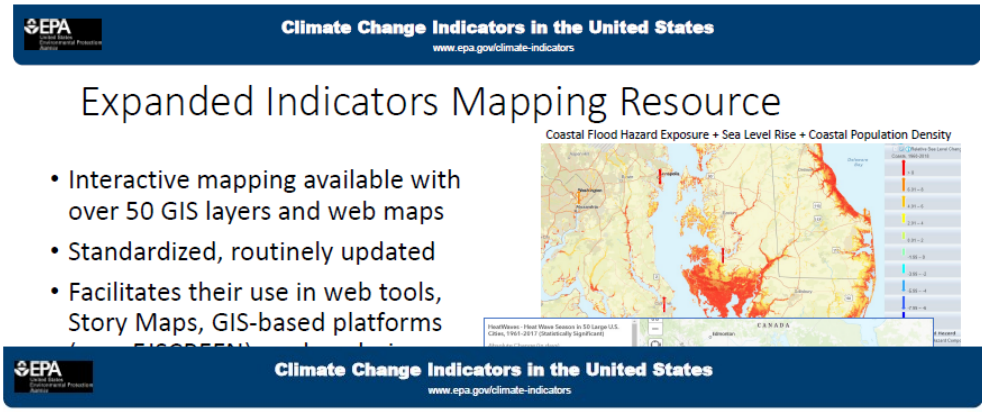


The first here is taking a more regional approach to the information, this could be taking the indicators set and developing what we would call feature stories based on state and/or regional level indicator information. So this slide is basically taking an example of that, where we could organize the indicators' information by the Northeastern US, for example, and then those indicators listed there like, river flooding, sea level, marine fisheries and Lyme disease are samples of the information we could package in that more regional approach, and hopefully have a different utility for users as well. Next slide, please. Another way is looking at how we can explore and share the indicators through those visualization tools I was mentioning, and one such way is this Climate Indicators Explorer tool, which is a new feature allowing users to filter, search, and interact with the indicator graphs. So this includes 18 different indicators and some special features, and we hope to add more in this upcoming year and beyond, but this is our first foray into this type of tool, and it does open on a separate webpage, it is accessible on our Climate Change Indicators Homepage, and again, you can really customize the views and-on-the-fly, download images and data.



And then another approach would be expanding our mapping resources, so users can interact with the maps, and access data and documentation, and use map layers with other GIS mapping tools. So we have over 50 of them available, they are standardized and again, as routinely updated as possible when these data's made available, and it can also allow users to explore the data by panning, zooming, clicking on different points and features in the maps, and then that will reveal data-specific or site-specific information. And an example would be if you take indicators maps, they could also be combined with other layers, and that would allow you to show relationships between multiple climate-related variables, population, [inaudible 00:40:30], demographics, economic data, et cetera. So again, it's a way to really facilitate the use of multiple different tools and package the information in a different way, and perhaps provide new information that wouldn't be obvious with different maps separated out.

And then the final approach I'm going to mention is utilizing Story Maps more. And this is again, a newer foray for us. We do have this one, that is the second bullet, the Overview of Climate Change Indicators, that one is really an overview, and it was in a collaboration effort with another agency, and it was to allow you to look at the importance of indicators and other federal climate indicator efforts. The other thing we are now



doing is this Community Connections Story Map, and this is a series of what we call topic-based interactive stories, and it's allowing users to visualize and explore regional and local indicator information in more detail. So example, topics of this include, you can see the Cherry Blossom Blooms in Washington, D.C. we also have ones like for Land Loss Along The Atlantic, we have Trends in Temperature and Drought in the Southwest, and another example would be changes in Alaskan River Ice Breakup, and that's with the dates over time.

And again, this is showing how people are potentially experiencing and in fact, interacting with the climate change that's occurring in their different areas, and of what the importance that might be for those communities. And next slide. And I will turn this now back over to Mike to wrap us up with the new efforts and areas of interest.

Mike Kolian: Discussion of New Efforts and Direction

In order to give people a sense of what directions we're heading, some of the new efforts that we have going on, it may be useful for the discussion set that we have coming right after this, but I just wanted to mention, we're pretty excited, in addition to a new updated website, we're producing a new report and it's a focused report, one on Seasonality, and we had seen just a little bit earlier, some examples of Seasonality in some of the indicators that we look at, but we've really tried to collect them all in one place.

And this is again, to provide some additional context to why these changes matter, if we're just reporting and profiling indicators and tracking them, people really don't understand well, "What does it mean if winter temperatures have increased a little bit faster than summertime?" So putting some of that into concepts, these things are interrelated, they're connected, they're associated, then there's downstream impacts when it comes to changes in temperature and precipitation. So be on the lookout for that, where we're just finishing some of the comments and peer review that it underwent, and laying that out.

Some other areas that we're interested in are measures of climate vulnerability, and so we're looking at this in a couple of different ways, and I'll show in just a moment. And also with other agencies taking the lead on sea level, temperature, precipitation like NOAA, they have a wealth of information on this. So what does EPA provide? And we're going to take a closer look at health, health has always been a challenging area in terms of indicators and climate, there's plenty of information data, but associating it with a climate signal, connecting it to changes in climate has been a little more challenging, it's still possible, and we've found some additional ways to do that.

Societal risk, where implied risk, increasing risk. Our people populations moving into hazard zones that are now becoming more at risk with changes in climate. So I'm talking the flood plain, wildland-urban interface, areas that are seeing more wildfires and more flooding, extreme heat. So is the population... In general, are there societal drivers increasing that risk? Economic implications, we have a few bigger-ticket indicators out there that give a sense of what these means in terms of dollars, but this is also just a challenging emerging area that we'd like to tackle, we do have a pretty extensive mature project at EPA looking into the future economic damages associated with climate. And so any connections we can put with our observed data to that, and then we've got both pieces.

Executive Order 12898 and Recommendations

White House Environmental Justice Advisory Committee and Justice40 calls out climate vulnerability indicators and references EPA's indicators multiple times

Climate Vulnerability

a. Percent of elderly living alone (US Census ACS)

b. Percent of car ownership (US Census ACS)

c. Tree canopy (National Land Cover Dataset)

d. Impervious surface (National Land Cover Dataset)

e. Green space (Normalized difference vegetation index)

f. Coastal sea level rise and flooding risk (NOAA, Climate Central Surging Seas Interface and US EPA Climate Indicators site https://www.epa.gov/climateindicators) Projected temperature change into the future (e.g. 2050 or 2021 NOAA, and US EPA Climate Indicators site https://www.epa.gov/climateindicators (e.g. In California, Cal-Adapt data has good information on project temperature changes that was used in the EJ Screening Method EJSM. Heat Islands check out NOAA, US EPA Climate Indicators site https://www.epa.gov/climate-indicators Portland State University, https://pdxscholar.library.pdx.edu/usp_fac/182/;

g. Frequency of wildfires or wilderness urban interface (WUI) fires (US EPA Climate Indicators site https://www.epa.gov/climate-indicators)

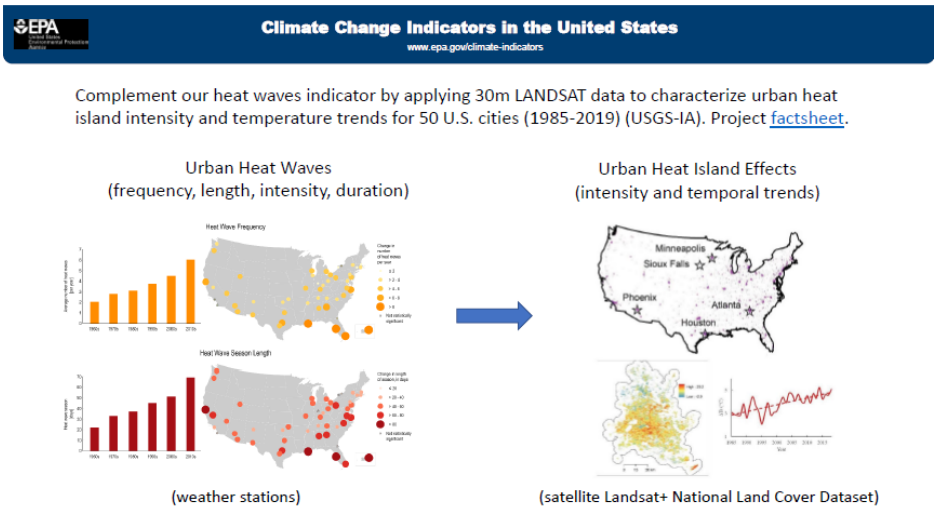
h. Ocean acidification (NOAA)

https://www.epa.gov/sites/production/files/2021-05/documents/whejac_interim_final_recommendations_0.pdf

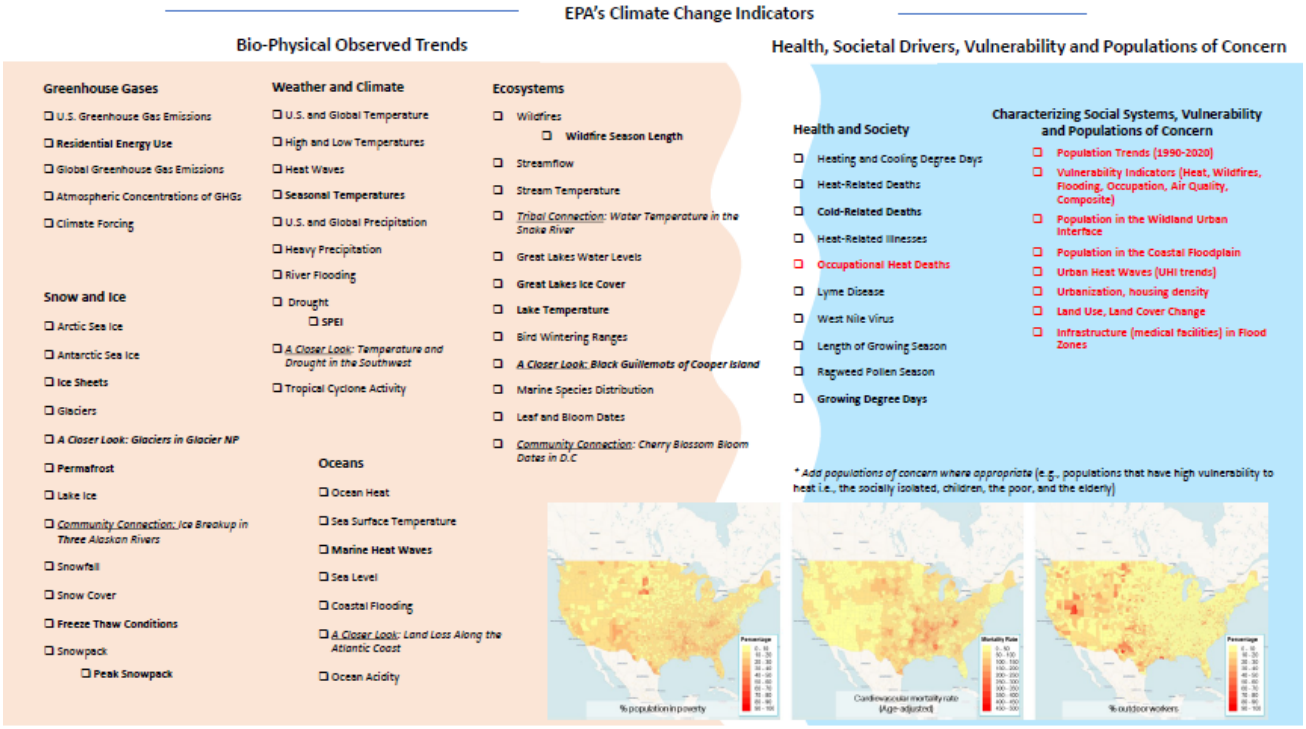
Informing better patient decisions, we have looked long and hard at this as well in the sense of indicators, but also what role indicators can play in these decisions, and then better ways to communicate, and I will roll through some of these slides rather quickly. So here's just the preview of the Seasonality Report, and some of the things that we'd look at, some of the key evidence related to timing, the timing of things, or the window of the wildfire season, the growing season, the ragweed season, the length of the growing season, the hurricane season, and what types of climate variability is occurring within that hurricane season.

So several interesting changes that express Seasonality here, some approaches to characterizing climate risk, exposure and vulnerability, and these aren't really new. I mean, we have been looking at population exposure, tide metrics, and population, tide metrics for many, many years, but this is really in context of climate and looking at hazard zones, the flood plain, Wildland-urban interface, which is that zone where there is a high growth rate in development, and right adjacent to vulnerable land.

And so these are frontline communities, these are riskier areas, typically out West, there is a lot of Wildland-urban interface in the East, but there aren't the wildfires that you have in the West. Urban areas in general are heat waves has indicator and pointed really for out the need there, additional couple information stations, we have a of weather

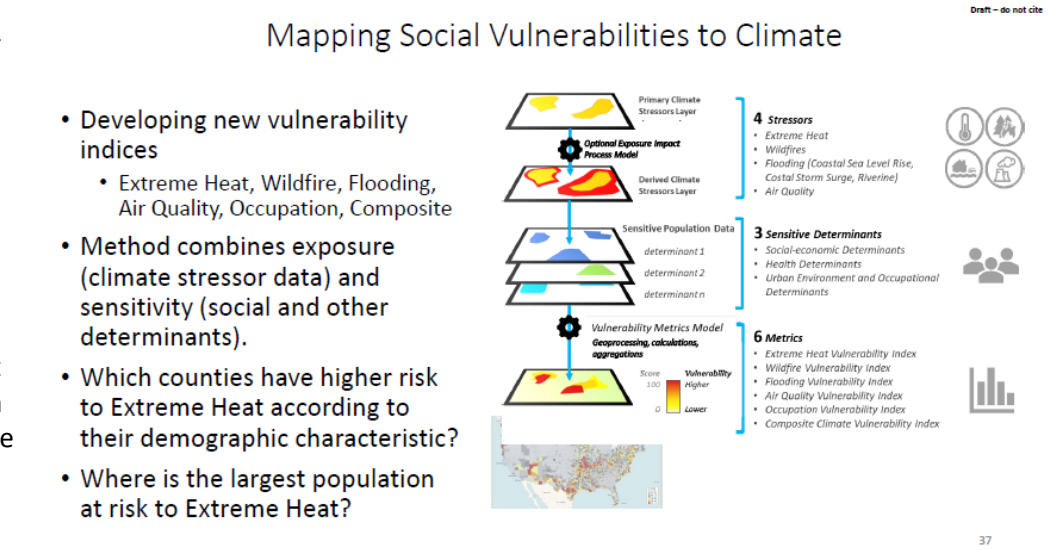


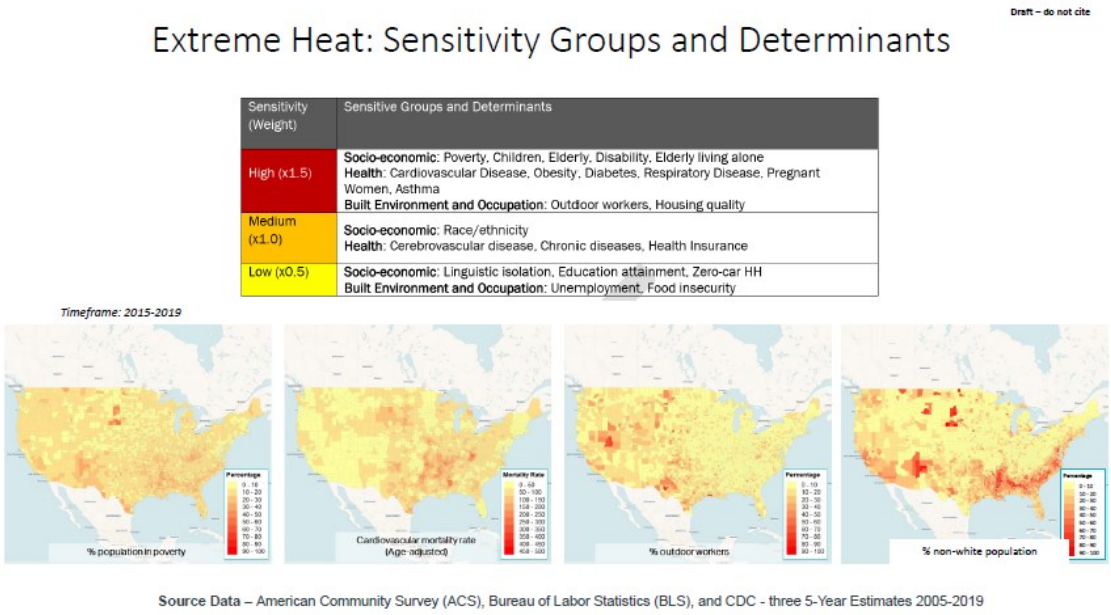
MSA or Metropolitan Area, but that's just not going to cut it when we're interested in looking at the urban heat island effect and where, and what specific communities are the most vulnerable on that risk to extreme heat. So each city has different profile, and we want to take a closer look using some USGS Landsat Data, as a matter of fact to do that.



And then approaches for characterizing risk and social vulnerabilities, this too is another area that's for many years been percolating indices, and metrics here, we're taking a closer look at, as you guys may know, there's a series of executive orders, but one in particular from the White House calls out climate justice and climate vulnerability, this points to EPA's climate indicators in several occasions and the recommendations. Here's just a smattering of things that they're wanting indicators on, or a tool to be created for expressing these in combination with other climate data. So this is just motivation or more impetus for us looking in this direction. Lisa had shown the full set of indicators earlier on a slide, if we really want to start merging in this, that the social systems, the other non-climatic drivers that are at play, that we also want trends on that are connected to many of these changes, then we need to start introducing population and other sources of data in combination.

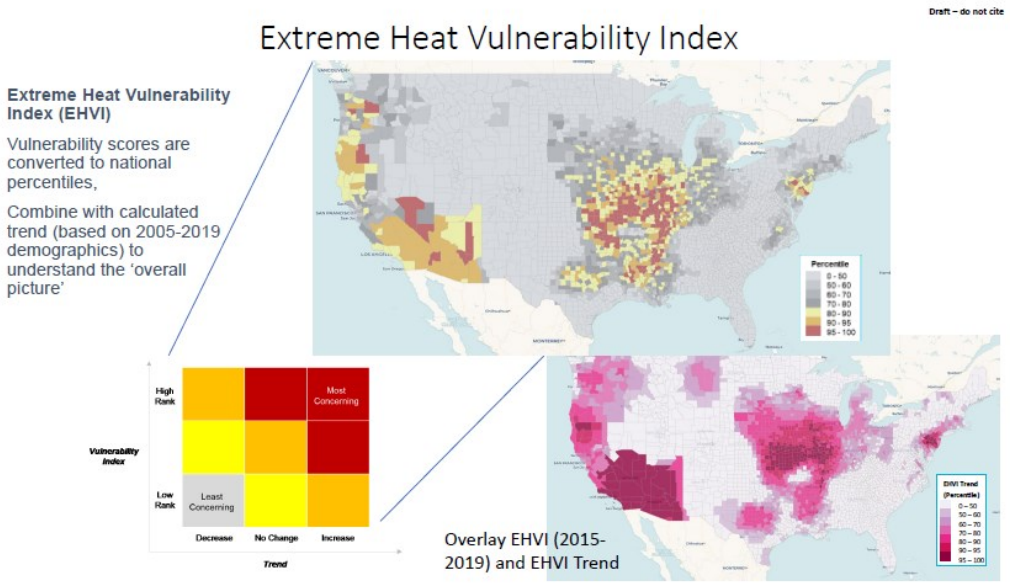
And these need to be joined and put together for a clearer picture of what's going on, and understanding how human health and society are impacted by these things, that's the general concept there. So this is a real quick depiction of the current heat waves indicator on the left, and again, we're looking in urban areas, which is unusual, when you're looking for climate and temperature in general, usually trying to stay away from urban areas, but here we're looking very specifically in urban areas. And the trend over time, we know temperatures or climate is baked into some of the other changes that are influencing temperature that are not climate-related, but this is acting on top of the urban heat island, intensifying that urban heat island. We want to take a closer look using land cover data sets and satellite data, 30-meter resolution to look at each pixel and start to really look at the urban heat island...



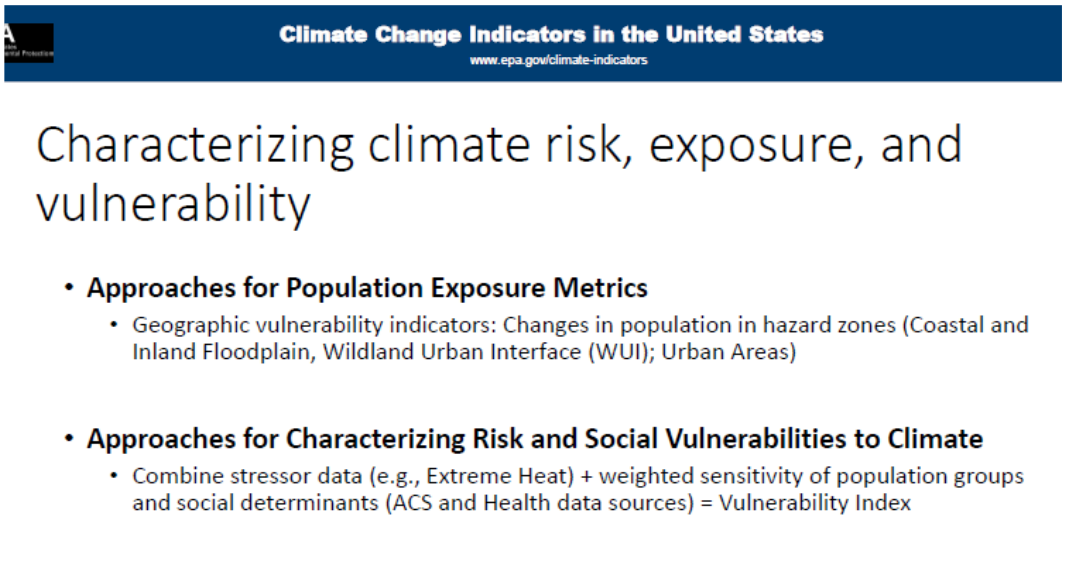


And start to really look at the urban heat island and it can do that with USGS data that is starting to become available so this is just one step in that direction and taking a closer look. And then, I'll just introduce this as more of a teaser than anything, this notion of the vulnerability indices or indexes, and we've chosen some of the bigger, thicker climate impacts to start with. Extreme heat, wildfire, flooding, air quality, occupation, and then we're considering that a composite of those five. Whether or not that's a good idea, we'll find out, but at the very least, those five. And this is an attempt to combine stressor data along with sensitive determinants and population data known to make a certain population more sensitive or more vulnerable to those impacts and this comes straight from the literature. Usually, you

can find a lot of this work has already been done so joining those two together to make this vulnerability index.



And we'll just give you a sense of what that might look like for extreme heat. We decided to use heat advisory days. This is available to us over time. At the county level, you can quickly aggregate it to the county level. This is anywhere where there's been a heat advisor has been issued and an excessive heat event or warning. And so, we can combine or compiled the number of days in which this has occurred as event days over time. Bring in the determinants, all the sensitive groups, there are socioeconomic, there are health-related determinants, and there are built environment and occupation-related things that, that you want to consider population-wise as to who and where there is more vulnerability to extreme heat and you combine those two, overlay them. We're looking at non-White populations, outdoor workers, cardiovascular, kind of a health-related indices for mortality rate, and the percent population in poverty. So all of these would be higher sensitivity in terms of weighing. And we're looking at all of these things, incidentally, not just the four that's featured and combining the two, weighing them getting a percentile rank, and even trying to trend that over time using some of the population data that we have available to us. So, it's a quick overview. In this case of extreme heat, we do a very similar thing with wildfire, but using some different datasets, a smoke dataset, a wildfire activity dataset, and hazard potential. So on the horizon, those are things that we're starting to cook up and think about for trends over time. With that, I think we'll stop there. And again, David and the committee here, we really appreciate this opportunity, has been a delight for us to join it today and we'll turn it back to you and the facilitators.



A Discussion Among Workshop Participants and the Presenters

> **Marianna Grossman** (Minerva Ventures) Member of the SRRR steering committee. My questions are about the "so what." The indicators are really important and I can see a number of different populations, insurance companies, zoning professionals, planners, emergency operators, who could benefit from using the indicators to respond to change. But I'm also interested in, can we use indicators to drive policy, funding and action so that we start to change the direction of the data? So for example, if we're really trying to drive greenhouse gas emissions, can the greenhouse or can we use that data to hold accountable the policy makers and the others who are making net zero commitments? Can we use that data for other factors that are like heat island? That's something that you can manage by adding tree cover and other vegetation, how we manage water and forestry. I'd love to see the indicators used to drive action and accountability.

Mike Kolian: Thanks so much for that question. I can take a quick stab at that, if that is for EPA in general. And it's like wanting to lead the horse to water and then actually making the horse drink - that's really where it's at. That is what we're trying to achieve with the set of indicators that we are putting together. It is often to make those connections and get as many as we can in order for people to understand that yes, we need to start making decisions.

This is about knowledge. This is about credible knowledge that we want to keep moving and tracking. Taking those next steps are a range of decision makers and folks. And so, EPA's role often, at least for us, it is stops somewhere before you get to those decisions, but we can bring you all the way there because we do national regulation of greenhouse gases and, but states, locals are doing it on many other levels and make decisions on many other bases. So I think there's a role for us, federal, kind of national scale. And then at some point, that gets picked up and well, EPA can't create each of those indicators. They can be made by others or you're left with some resources and impetus for doing that.

Marianna Grossman: This may be coming from a structural point of view, but I would love to see the legislation that's in Congress, pairing with your indicators to say we're setting these targets and we're going to hold ourselves accountable, and EPA's indicators are going to show us and other government are going to show us if we're making progress or not on these big promises that we're making. Otherwise, it's just a lot of motion and we're basically watching the ship head into the iceberg. Well, there is an iceberg ahead and we're just documenting decline and catastrophe instead of using that to hold ourselves accountable for having policies that are at the scale of the challenge.

Mike Kolian: That's a great, that is a better way to think about it and taking it to that next level. And if Congress passes legislation, EPA could be charged with coming up with those indicators or taking that next step or being funded to do that with resources, with smart people, and take that on.

Marianna Grossman: Just as there is an Office of Management and Budget on the financial side to hold us to our budgets. This would be holding us to our climate indicators that are things that we can change and in the short-term time scale. And, I think our other questioners have questions. Although, I just going to sneak in one more, which is how, what audiences are you thinking about for reaching this information take at it really actively used?

Mike Kolian: In general and here too, I'll start and defer to Lisa and Lauren for their thoughts because they're even closer to some of the other audiences and general audiences that we have, but this is... One of our biggest audiences is EPA itself, and we have to think internally and think across the agency

offices and programs. That's one. It is not the only one and it's not the only one that drives us, but the other is educators and the general public. Educators have been, historically, a big user contingent for the information for the resource. They've been the ones that have continued to visit the site and asking when we are going to update this again. And so, it's been in grade schools, high school, and at the college level that we have seen the indicators used. So, that's really empowering. That's a nice resource, set of audience users. And then lastly, another audience group that's very important to us is the other agencies, the other contributors, the other partners that we have in advancing sort of the state of knowledge. And I'll stop there and let Lauren chime in with her thoughts.

Lauren Gentile: To your question, everything Mike said is exactly right. Some other ways we can look about it though. I was mentioning sort of the regional configuration of indicators, so that could potentially reach a new suite of audiences, potentially maybe at more of the state level because then, they would be able to more easily grab that information that's relevant to their area and to their region so I would say. And potentially down to the local level, if they're looking for broader context information within which to situate their own local climate change impacts and changes in general, so I would say that might be another newer audience for us to hopefully be able to tap into. And to Mike's comment about the educators, that's definitely one and I think potentially moving forward, we could even see it from the student's side themselves in wanting to utilize indicators and perhaps their own assignments or reports and things like that as, again, that documentation and context setting of what has happened and is currently through whatever that timeframe happening now. So that might be, again, another audience with which to focus on.

Abdul Kahn, (California Department of Water Resources), Member SRRR Steering Committee: I think these are wonderful progress in terms of communication in the indicator space, but I have three questions which are sort of related. First one, I'll go with, start with what Mariana said. So I was just thinking in terms of the audience, that how we lair communication of indicators for a wide range of audience, from technical specialists to resource managers to policy makers, and executed to the general public? And these living, when I started with technical specialties to the general public, I was thinking about higher level of complication detail to sort of more summarized understanding of the information.

I'll talk about the other two questions and then let you, these are all related. The second one is I truly feel that there is an opportunity. How can we harness the power and broad presence of social media platforms to advance communication on indicators? And the third one, which directly relates to the high school, college and university students. How can we build apps perhaps, for cellphones and tablets, to communicate this information to the younger generation?

Mike Kolian: That's a great set of questions and the layering is a really neat one too to think about that there are technical specialists and technical people that use the information that contribute to the information and need it in a certain way for their own purposes, for their own communication. All the way down to the general public, one other little audience here so are those that still need to be convinced and there are still those out there. So, do we need to go beyond preaching to the choir that we've talked a lot about? Our traditional users are people that are picking this up are educators. But, are there others that we can get them to think about this in a little bit of a different way to really understand. I recognize why this would be important or why we would need to watch this and do something about this.

So there's that and there's a little bit less of the really ardent contrarian view, but there are still people that, these are such a big deal. These are... There isn't a lot to worry about quite yet. So that aspect of

the totality of it all, all of these things taken together, social media, and I'll just hit on this briefly outstanding way to get the word out, really simple messages there too. We have been pretty hamstrung in the previous administration in doing any kind of work like that. So now, we're actively pursuing that. That has been a big component of our communications group and the Office of Public Affairs, in fact, are asking us. But, there's even more clever ways, I think, beyond social media to keep advancing that message. Is there fatigue? This is another thing that has come up. People hearing bad news just repeatedly and constantly and every time you turn around is their climate fatigue.

So, there needs to be a balance. It needs to be strategic. It needs to be timed. During heat events, it'd be great to be sending out some messages and telling people how to prepare, how to be advised, and how to address certain things. I'll stop there. I know you had... Oh, the cellphones and real-time information. There are apps that we have used for air quality and for wildfire work that is pretty real-time and allows people to communicate these advisories are things that happen in real time. The indicators, as you know, are those long-term trends. They're a little bit different. It's a slightly different aspect of what we're looking at. However, for all of these trends, all of these things, we're wanting to know when is the start of the policies and when do we see extreme heat and knowing about that ahead of time, forecasts have become useful. But, there are two that starts to get outside of at least the wheelhouse of what we're doing and then I'll just see it more. And, who wants to chime in from her perspective?

Lauren Gentile: A couple of quick things to your first and second question. I think that we do try to tackle a wide range of audiences just because of, inherently, the way indicators are. It is very technical, but it also does lend itself nicely to communicating in very real terms in ways that people can relate that other complex climate-related information sometimes is a lot more difficult or is down in the future. Why should I care because I may be dead by the time? It's going to happen, but we do have technical documentation and that I would say to your question is where those technical analysts and specialists would go for that sort of very detailed information and not simple. It's how we did it, and the data. That also always includes when was the data updated as well. So it's a track record. So I would say that would be definitely where your technical individuals would go to and then the website itself is meant to be public facing. And so, that information is meant to be towards the general public and middle to high school level understanding. In terms of reading and comprehension, that is where that general public information comes in. And then we, of course, through briefings and various products that we develop, can sort of try to fit within that whole range.

And then to your third question about the social media, one other idea I was thinking about was potentially tying the indicators now that we do have more latitude to use social media. As Mike said, we were very hamstrung, but now that we have those avenues open, there's opportunities, I think, to flag indicators in conjunction with some of the extreme events that we are seeing and witnessing on what now seems to be a very relatively regular basis. And so, we'd have to do that very carefully, but I do think it could be that, again, context like, Hey, this extreme heat wave out in the Pacific Northwest just had massive impacts recently. Here is the historical trends for this area. And here, we are changing yet again. So I think that's where you could potentially make those connections in a reasonable way and flag them again because it's on social media for those younger generations where that is where they tend to get their information, rather than just going to a website.

Rhonda Kranz, Kranz Consulting and SRRR Steering Committee member: I want to say on that last section that it's really exciting to see the creativity and attempts to look forward and some of the things that you're planning on doing. I really liked the social vulnerability mapping idea. I do have a couple of questions, quick questions. Is there, there's a lot of focus on the social. There is some, there's use, a

biological and ecological issues for indicating climate change, but is there also some focus on climate, the vulnerabilities, biological, ecological ecosystem of vulnerabilities?

The other quick question and maybe these can come out in the breakouts if there's a time to talk about them now, but going from Marianna's idea of working from what the needs are, so these mapping and the other ways you're trying to tease apart, what are some of the factors involved in what we're seeing? Can you go to the communities and what are the kinds of things that they're trying to understand for their community and then as opposed to waiting for them to do it to be able to connect and work with some of those communities? Maybe you already are to see what is it that the local groups and agencies are trying to find out so that they can actually figure out the issues in their own communities?

Mike Kolian: Great questions. And I'll start with the biological and ecological vulnerabilities, and that's a great point to make. I was involved in a really, really nice workshop that state of California put on. They have their own state, a set of indicators, and they're ready for another release. And so, they wanted a workshop and it was really nice, kind of, symposium. But they really had some great speakers from the ecological perspective. Logical perspective, stream health, the... We track temperature. We track lake and stream temperature, water temperature, surface temperature, and there's all kinds of reasons for that and all of these systems are a little bit different, they're vulnerable in different ways. There are certain snow pack areas and watersheds that are vulnerable, more vulnerable than others. And people are thinking along those lines, they are using the information for that. We haven't been able to take things that far in terms of indicators, but I can tell you from my experience with that and working with others in USGS and folks that are looking in I think of hydrologic conditions. They are looking at those vulnerabilities in that same kind of way that we would for people. Another interesting thing that came up there was heat waves are lethal to plants just as they're lethal to people. They're Joshua tree is under siege right now because of, there are extreme temperatures above tolerance thresholds. They're worried for there, the survival of some plant species in certain areas. So there's, there's definitely a reason to do that. And another really quick example I'll give you is, we are working with Chesapeake Bay program and the set of states and organizations surrounding it. And their whole approach is resilience, one of resilience, and all of their, they only use a set of half a dozen climate related indicators that we would traditionally put together. All of the rest of them are kind of more traditional ecological resilience oriented indicators. And it's a really neat perspective, very comprehensive perspective. So we have some of those examples. We just haven't been able to go that deep in getting involved in all of the, Great Lakes is another area that's done a lot of regional code cohesive thinking along those lines, but, and I'm blanking now. You had another great question right after that.

Subijoy Dutta, S&M Engineering: I work for Loudon County. I worked for EPA until 2012. I worked on various remediation sites, RCRA, CERCLA, all those projects I did, but I was on a detail to George Washington University and I worked on the Loudon County environmental indicator project. I must tell you, I'm so pleased that you guys are now taking that up again on environmental indicators, excuse me. It was missing for a while. And what I kind of, I listened to your presentations, but I think what I was missing is, the ground reality of the things that you are monitoring, you were plotting on the GIS. And I did that too, because GW had, it still has very good GIS facility in their geography department. What I was thinking is the vegetational stress, the forest cover, how the forest cover, fracture in the forest cover causing various bird species to migrate and go because predators get them if they're not deep inside the forest. So those sort of things, I just thought this sort of areas, plus I also had, we used to go out and look at the Goose Creek and the development was the highest, third highest in us in the early 2000's, 2004, 2005, I started in 2002 and then I came back to EPA. But during, with that development, the Goose Creek could be all red at times. And we were monitoring the totals suspended solids,

dissolved solids and various other factors in the water. Of course temperatures, you mentioned, but those water qualities compared to your forest cover, compared to your developments, we had one indicator, which is really simple, but great one, like we had a student who we assigned him to take pictures of some intersections, which were not developed. So he took in 2001, 2002, 2003. But what I was trying to say is, those are the types of indicator are you considering?

Mike Kolian: Those are great environmental indicators. We do have the Office of Research and Development at EPA which works more on those than we do. There is 's a broader set of report on the indicators that some of those brush up against, but that's how I can answer it at least in a very high level. But the thanks for those comments, those are useful.

Comment from Breakout Groups

David Berry: Ed Henry of the Natural Resources Conservation Service of USDA brought up the importance of looking forward with regard to adaptation and resilience. And he gave examples of thinking about water storage in times of water abundance, additional water storage. So that in times of great drought, we would have a bigger buffer.

And then I made a quick comment with regard to implementing the indicators and acting on them. It is usually different offices and groups of people. The people working on information and indicators are not in the policy offices. Those tend to be the senior executives reporting to the political appointees. So one of the goals for roundtables like this one, is that when people in the government working with information share it brilliantly as happened today, other people in the workshop who work elsewhere in academia, in nonprofits, in business or in advocacy, can take action that federal employees themselves can't take to engage with the political appointees.

About the Sustainable and Resilient Resources Roundtable

Our Mission

The roundtable mission is to promote sustainability and resilience of resources critical to ecosystems and communities that depend upon them. Increasing the level of ecosystem and community sustainability and resilience requires an understanding of the science underlying ecosystem functioning and addressing challenges in policies, programs, and practices. This requires changing our behaviors as individuals, communities, businesses, organizations, states, and nations. Recognizing challenges at local and regional levels can help us opportunities to find better solutions at larger scales and can create pathways for meaningful action. Collaborative research and sharing common solutions can optimize resources and accelerate positive change. The roundtable works to achieve this through engaging knowledgeable people and partners from the business, government, academia, and nonprofit sectors to improve the understanding, management, utilization, conservation, preservation, and restoration of ecosystems and the services they provide to communities.