00:00
okay so I will get started all right so
00:04
I'm going to talk about my research in
00:07
Acadia I'm specifically looking at
00:09
phenological changes um in the plant
00:13
communities in Acadia and I did this
00:15
through two different approaches the
00:18
first was hiking lots of mountains and
00:20
the second was with an experimental
00:22
garden and so if you joined our webinar
00:26
last summer I talked a bit about the
00:29
hikes the transects to look at
00:31
phenological change um but I don't think
00:34
I actually got to the garden stuff at
00:36
all so today I'll be giving an update on
00:39
our data I'm an analysis from the
00:42
transects and really digging into the
00:44
garden work as well and as you know I'm
00:48
seeing signs of the seasons people
00:51
phenology is the timing of seasonal
00:54
biological events and ecologists such as
00:57
myself are really interested in
00:59
phenology because when we think about
01:03
how climate change is affecting

01:05
ecosystems and ecological processes
01:08
phenology the timing of seasonal
01:10
activities of animals and plants is
01:12
perhaps the simplest process in which to
01:14
track changes in the ecology of species
01:17
in response to climate change it's
01:20
something that's really visible and
01:22
measurable and it makes this kind of
01:26
immediate connection to other people so
01:29
I feel in a lot of ways that I'm lucky
01:31
as a researcher because it's easy to
01:33
explain what I do what I'm sitting next
01:36
to someone on a plane or I'm if I just
01:40
happen to meet up with friends um and
01:43
there's someone new in a group it's easy
01:45
to say that I look at plants and when
01:48
they flower and leaf out and often
01:50
people will have really personal
01:52
experiences tied into phenology you guys
01:54
from things like maple sugaring or their
01:57
own gardens they'll remember years in
01:59
which they planted things and then there
02:01
was a late frost and they lost all of

02:03
that effort and they'll remember years
02:05
like 2012 when the spring was so early
02:08
that things were just leafing out and
02:10
blooming like crazy in February
02:13
um and I used the back of this slide of
02:16
2016 as the hottest year so far because
02:19
2016 was the last year that I did this
02:22
fieldwork in Acadia National Park um
02:24
this was all part of my PhD dissertation
02:26
and so I was working in Acadia starting
02:29
in 2011 but doing the fieldwork that
02:32
I'll talk about in 2013 2014 2015 and
02:36
2016 so I just want to introduce you to
02:41
the two big questions I'm looking at the
02:44
first area the first is how can we
02:48
rapidly assess contemporary leaf out of
02:50
flowering changes in the complex
02:53
landscape anyone who's been on that
02:55
desert island or hikes in Acadia knows
02:58
that this is a pretty interesting
02:59
landscape you can go from sea level and
03:02
be in a rocky intertidal area and then
03:06
within a couple miles and often under an

03:10
hour you can be on top of the mountain
03:12
in basically a sub Alpine community and
03:16
so there's a lot of terrain complexity a
03:21
lot of elevational complexity and a lot
03:23
of education complexity and so trying to
03:27
understand or how to how to really get a
03:29
handle on what's happening across on
03:32
such a heterogeneous landscape it's an
03:37
intriguing question 4 million managers
03:39
who want to get this kind of data and
03:41
for ecologists who are interested in how
03:44
do we approach something like this I'm
03:47
and then my second question I'm looking
03:50
at what's driving this population level
03:53
differences and we thought responses
03:54
within Acadia so what I'm talking about
03:57
interest specific differences those are
03:59
differences within a species so looking
04:02
at lowbush blueberry and if you think
04:05
about it
04:05
blow bush blueberry you don't just walk
04:08
out your door at the end of April and
04:10
there's a day where just boom every

04:13
lowbush blueberries leafing out you'll
04:15
notice some lowbush blueberries leaping
04:17
out early in the spring and some of them
04:19
holding out until much later and so is
04:23
that um is that a response
04:26
two differences in local microclimates
04:28
or do some populations of lowbush
04:30
blueberry have different programming for
04:34
when they are going to leaf out or how
04:35
much morphs or heat them or spring
04:39
whether they need before they leaf out
04:41
so those are the two questions they'll
04:44
be addressing today and I just wanted to
04:47
take a moment to acknowledge how lucky I
04:50
was to be able to do this work in Acadia
04:52
National Park where most of my
04:54
dissertation research really looked like
04:56
this I got to spend time in a beautiful
04:58
location I'm hiking and sitting outside
05:02
in gardens and writing things down in my
05:04
notebook as I'd noticed them so I'm it
05:07
was really an incredible experience and
05:09
I have a lot of people at Acadia

05:11
National Park to think but specifically
05:13
Abe Miller rushing the science
05:15
coordinator and everyone at resource
05:17
management who helped me out with this
05:19
project so I'm going to start with the
05:22
the hiking the observational transect
05:24
and so this gets into the question how
05:27
can we rapidly assess contemporary leaf
05:29
out and flowering changes in a complex
05:31
landscape and I asked this question
05:35
because I came from a lab at Boston
05:37
University
05:38
that has focused on the Rose Concord in
05:41
Massachusetts and so this is our classic
05:44
figure from the concord data set we're
05:49
on the x-axis
05:50
there's mean spring temperatures from
05:52
Cold Springs all the way out to Warm
05:54
Springs and the y axis goes from the
05:58
19th of April so kind of early springs
06:01
up to late May and you can see that
06:05
there's a really clear relationship
06:07
between spring temperature and mean for

06:10
flowering day we're in earlier in warmer
06:13
Springs things are flowering earlier and
06:16
in colder Springs things are flowering
06:18
later and this is um this nice simple
06:22
linear regression gives us a number to
06:25
put on that where we can say for every
06:28
degree Celsius that it's warmed the
06:30
spring or the first flowering date is
06:32
advancing 3.2 days and that's a negative
06:35
3.20 because it's advancing it's
06:37
happening earlier in the year
06:40
and so this was the lab that I was
06:41
trained in as a grad student and this is
06:44
the kind of work that they had been
06:45
doing in Concord Massachusetts since the
06:47
early 2000s
06:48
and it's really interesting work but it
06:50
depends on having a huge historical data
06:53
set from someone like Henry David
06:55
Thoreau because in order to make this
06:57
figure where each individual dot on that
07:00
figure represents one year where you
07:04
have the mean spring temperature for

07:06
Concord in that year and the mean first
07:08
flowering date for a suite of about 30
07:10
species in that year this is the data
07:14
behind that so you can see that the
07:17
years stretch from 1852 all the way up
07:20
in this case to 2000 I think this is
07:23
2011 and the years continue to
07:27
accumulate as the Premack lab continues
07:30
to work in Concord but to make that one
07:33
figure took a lot of effort and a lot of
07:36
data and when I started my dissertation
07:38
research in Acadia National Park I
07:40
didn't really have time as a new PhD
07:43
student to put in 20 25 30 years of
07:48
observing phenological change in Acadia
07:52
National Park I figured I had about five
07:55
or six years as a PhD student so I
07:57
needed to come up with a way to rapidly
07:59
assess leaf out in flowering times and I
08:05
was looking at the historical records
08:06
for Acadia National Park and there's a
08:08
lot of historical botanical work from
08:11
Acadia it was this huge hot spot at the

08:15
end of the nineteenth century for
08:16
botanists to come and collect our Burien
08:19
specimens there's a beautiful flora that
08:21
was written in 1890 or published in 1894
08:24
from fieldwork that dates back to the
08:26
early 1880s but there weren't
08:29
phenological records so all of these
08:32
folks who came to Acadia to boughten
08:34
eyes they were mostly wealthy elites
08:37
from Boston and Philadelphia New York
08:39
and they had the leisure time and they
08:41
had the botanical training to do this as
08:44
a hobby and they would do this while
08:46
they were summering and by definition
08:48
summering means that they weren't here
08:50
in the spring when things are actually
08:52
leasing out
08:53
and flowering and the folks who lived on
08:56
the island year-round and may have been
08:57
recording those observations or maybe
09:01
didn't have time to record those
09:03
observations because they were working
09:04
and trying to prepare the estate's for

09:07
these wealthy elites if they did record
09:09
them they weren't archived so I couldn't
09:12
find historical records of leaf out and
09:15
flowering phenology for Mount Desert
09:17
Island and basically I was starting from
09:20
scratch and needed to come up with a way
09:23
to get a lot of phenology data very
09:25
quickly and that's where the the
09:28
complexity of the landscape actually
09:30
helped me out because as you can see
09:33
from this map of Mount Desert Island
09:34
there's a lot of complex terrain there's
09:39
a lot of elevation gradients and anyone
09:41
who's hiked Cadillac or sergeant or pema
09:43
tech knows that when you start at the
09:45
base of those mountains and you're
09:47
wearing shorts and a t-shirt by the time
09:50
you get to the top you've added a couple
09:51
layers you might be at the summit of
09:53
Cadillac and you've put on a fleece and
09:56
a hat because you have just hiked
10:00
through a bunch of different
10:01
microclimates and so you've actually

10:03
experienced different types of springs
10:05
as you've hiked from the low elevation
10:09
trailhead up to the summit of these
10:12
mountains and so taking advantage of
10:15
those micro climates in that elevation
10:16
gradient I could collect a lot of data
10:19
in a single year by really breaking the
10:21
mountain down into different zones and
10:23
so that's what I did I was looking at
10:26
seven elevation zones on three mountains
10:30
Cadillac Sargent and Pema tech I
10:32
monitored each Mountain twice a week
10:34
hiking up the North Ridge Trail and down
10:37
the South Ridge Trail I'm starting in
10:40
early April and ending on June 30th and
10:42
June 30th was our cutoff because we were
10:44
interested in spring flowering plants
10:47
and so we needed kind of a hard date to
10:51
define our spring I did this for four
10:55
years starting in 2013 and ending in
10:58
2016 that's correct I looked at 30
11:02
species all together but I'm going to
11:05
present data for the nine

11:07
common species so things like lowbush
11:09
blueberries that grow across that entire
11:10
elevation gradient we were able to
11:12
collect a lot of data very rapidly
11:15
because if you have three mountains and
11:17
seven elevation zones in a single year
11:20
you can look at 21 different populations
11:22
of lowbush blueberry and still get 21
11:25
data points for that one species very
11:29
quickly and so this schematic kind of
11:33
helps to show how I divided these
11:36
mountains I'm at the top you can see the
11:39
trail signs for the three mountains
11:41
sergeant
11:42
pema Tech and Cadillac um and I've
11:45
divided this imaginary lysates cadillac
11:48
mountain into the north and south
11:49
aspects and then i'm divided on the
11:55
elevation zones into different sites so
11:57
on the north as you move through the
11:58
first elevation zone your insight one
12:00
and then you get into the second
12:02
elevations on its site to across all of

12:05
these mountains I had my cut-offs as
12:07
zero to 600 feet of elevation then 600
12:10
to 900 feet of elevation site free went
12:13
from 900 feet to 1200 feet and site 4
12:16
which is the summit went from I 1200 to
12:20
the summit and then those exact same
12:21
boundary is found the south side when so
12:25
that was how I basically sliced these
12:27
mountains into different elevation zones
12:29
and I wanted to see how the microclimate
12:32
changed as he moves across these
12:34
elevation zones and so I put out
12:36
temperature loggers um the big picture
12:39
with the hand shows what these little
12:41
loggers look like they're they're called
12:43
pendent loggers and they hung them from
12:46
corner of better pieces that white item
12:51
in the second picture with a little tag
12:53
on it was the shield so that they
12:56
wouldn't be exposed to full Sun and then
12:58
experience temperature spikes so the
13:01
corner of gutter pieces that are upside
13:03
down allow air to move through the

13:05
corner gutter piece but protect the
13:08
pendant from full sunlight and these
13:10
were hidden off the trail I had one in
13:12
each of those elevation zones on the
13:15
north ridge side and one in each
13:16
elevation zone on the south side
13:19
for a total of seven different lagers
13:22
per site
13:23
um and these were great
13:27
I remember going into Home Depot when I
13:29
was putting these together and buying 21
13:33
corner gutter pieces and the really nice
13:35
gentleman in Ellsworth who was helping
13:37
me out had a very confused look on his
13:40
face he said what shape is your house
13:43
but they turned out to be a really cheap
13:45
and effective sunshade and we hung the
13:48
pendant loggers from the middle of the
13:50
corner gutter piece with a zip tie we
13:53
drilled a hole in the top and just
13:55
headed in with a tag that said if you
13:56
found this um please don't move it it's
13:59
part of Acadia National Park research

14:00
and there was contact information for
14:04
the resource management division so
14:07
those recorded our temperatures and we
14:09
were specifically looking at spring
14:11
temperatures so we wanted to know what
14:13
was happening in March and April and so
14:16
to give you a little insight into how
14:19
this worked out it turns out that it's
14:21
not as simple as saying it's cold at the
14:24
summit and it's warm on the South
14:26
southern aspect of these mountains and
14:29
the lowest elevations are the warmest
14:31
spot so to show that I'm just going to
14:34
fill in the Cadillac 2016 and me and
14:37
spring temperatures these are March and
14:38
April temperatures so the summit was the
14:41
coolest spot that spring but then um it
14:45
kind of bounced around and it turned out
14:48
that on the north ridge on the lowest
14:51
elevation site it was really warm and if
14:54
you hike to the north ridge of cadillac
14:56
you know there are some of those open
14:57
exposed rocky areas and you go through

15:00
on some really kind of like warm pine
15:05
forests but on the south ridge side if
15:08
you've hiked the the cadillac south
15:11
ridge trail recently you start off by
15:13
hiking through about a mile of a jew
15:16
steep closed canopy conifer forest where
15:20
it's really cool and so the microclimate
15:23
is really complex
15:26
when you think about where the coolest
15:29
and warmest spots on the mountain are
15:31
and so for the rest of my analysis
15:33
you're going to kind of forget about
15:35
where you are on the mountain and we're
15:36
just going to match up the phenology
15:40
observations with the mean spring
15:42
temperatures so we'll be showing my
15:45
results on a figure that looks like what
15:48
I showed from Concord Massachusetts the
15:50
x-axis we have mean spring temperatures
15:52
these go from zero to three point five
15:55
degrees Celsius and the y axis goes from
15:58
on so mid-april on through mid-june for
16:04
the date of leaf outs and in this case

16:06
I'm instead of having each data point
16:09
represents a year where we have a mean
16:11
spring temperature for all of Concord in
16:14
that one year and then a mean leaf out
16:18
date for all of the species in that year
16:20
I'll have a data point that represents a
16:23
single elevation on a mountain with an
16:28
aspect and a single species so um a data
16:33
point will represent for example the
16:34
summit of Cadillac for lowbush
16:37
blueberries so it's going to look a
16:38
little bit crazy for a second and I'll
16:40
try to talk you through that here's all
16:42
of the data and we had temperature data
16:45
for 2014 2015 and 2016 it took us a
16:48
little bit longer than expected to get
16:50
those temperature loggers deployed this
16:52
is three years of data across 21 sites
16:55
and I put up all of the data for the
16:58
nine species the nine most common
17:00
species at the top of the figure there's
17:03
photographs of six species and those are
17:06
the six species for which we have

17:07
significant relationships between leaf
17:10
out and mean spring temperatures so I'll
17:12
just read across the top the first
17:15
picture is huckleberry the second one is
17:17
chutes Laurel I'm Canada Mayflower
17:21
excuse me a 3-2 cinquefoil lowbush
17:24
blueberry and wild reason I'm and so on
17:30
the six lines that are visible in the
17:36
figure represent the regression lines
17:38
for those six species so when we look at
17:41
those
17:42
it can be a little bit overwhelming it's
17:45
kind of a giant plot of lines but I'll
17:49
just let you know that in each case
17:51
they're leasing out earlier in warmer
17:54
years and even for the three species
17:56
that did not have a significant
17:58
relationship that pattern remains true
18:01
and so for example the wild reason is
18:05
weeping out 6.1 days earlier for each
18:09
degree Celsius that it warm so this the
18:12
regression coefficient on that slope is
18:15
6 point 1 or negative six point 1 and

18:17
the on the huckleberry is leasing out 1
18:24
point 7 days earlier for each degree
18:26
Celsius that it warms so huckleberry has
18:29
a significant relationship but it's not
18:31
as dramatic as the the wild raisin so on
18:38
I'm going to show the same type of
18:40
figure for a flower and date um these
18:43
are the same nine species across the top
18:46
we have six species that have a
18:47
significant relationship between
18:48
flowering and mean spring temperatures
18:51
here's all of that data once again the
18:55
six species in this case our chokeberry
18:57
bunchberry huckleberry she floral three
19:02
to cinquefoil and lowbush blueberry and
19:05
in this case the slopes range from three
19:09
point six days earlier so that's the
19:11
chokeberry is its flowering three point
19:14
six days earlier for each degree Celsius
19:17
increase in temperature and she floral
19:22
represents the smallest regression
19:26
coefficient at one point eight days
19:27
earlier for each degree Celsius that

19:30
it's warming and again every single
19:32
species is showing this pattern these
19:34
are the six with significant
19:37
relationships and when we zoom in on
19:41
that to look at the difference between
19:42
Mount Desert Island and Concord we have
19:46
the same pattern they're all advancing
19:49
their phenology in response to warmer
19:52
temperature but for these four species
19:55
that we monitored both in
19:56
Concord and on that desert island the
20:00
magnitude of that shift is greater in
20:03
Concord across the board and that's true
20:05
also for flowering species and there are
20:09
again four species that we monitored on
20:12
Mount Desert Island and in Concord
20:13
flowering and again they're all shifting
20:17
earlier in response to warmer
20:19
temperatures but the magnitude of that
20:22
shift is greater in Concord
20:24
Massachusetts so we were able to look at
20:30
changes in phenology in response to
20:33
different temperature regimes but that

20:35
required having a person like myself or
20:39
some of my undergraduates from college
20:40
of the Atlantic hiking three mountains
20:43
twice a week so there was a lot of
20:44
hiking happening to record all this data
20:46
and we really wanted this kind of work
20:51
to continue to happen
20:52
I mean phenology monitoring is as you
20:55
know it sighs the seasons very important
20:58
to track changes and how plants are
21:01
responding so a second part of this
21:04
analysis was to look at different
21:06
monitoring strategies so what would
21:08
happen if in the future we were only
21:10
able to keep up this kind of work on
21:13
Cadillac or only on Sargent and Temasek
21:16
what would happen if we only looked at
21:18
the southern aspects of these mountains
21:20
or the northern aspects of these
21:22
mountains or just a low elevation sites
21:24
or just the high elevation sites and or
21:28
what if we did this for a fewer years or
21:31
more years and so we took the most

21:33
common species and that was a low Bush
21:35
blueberry the one that we had the most
21:37
observations for across our three years
21:39
of data and we looked at what would
21:43
happen if we subset the data that we had
21:45
collected over those three years into
21:47
those different categories so um we
21:51
calculated what that change in phenology
21:57
per degree Celsius would be so like what
21:59
the slope would look like along with the
22:01
standard error so in this figure you can
22:04
see the estimated flowering response the
22:07
original model refers to
22:10
what happens with all of that data so
22:12
for flowering lowbush blueberry um
22:16
that's a negative 2.8 regression
22:20
coefficient or it's advancing 2.8 days
22:23
per degree Celsius and if we broke it
22:27
down by mountain and looked at just
22:30
Cadillac or just Sgt pentateuch Cadillac
22:33
and Hamitic Cadillac and Sergeant you
22:34
can see that that regression coefficient
22:37
moves around and when we take out the

22:40
Cadillac data and just look at data from
22:42
Sargent and Pema check that regression
22:44
is no longer significant that's why that
22:46
little bar is now red so Cadillac is
22:51
important in terms of being able to
22:53
provide enough data across enough
22:57
microclimate to get a good estimate of
23:00
how flowering is responding to
23:03
temperature we did the same thing
23:05
looking at aspects so south aspect
23:07
versus north aspect and you can see
23:10
again that the north aspect only is not
23:13
significant so it didn't cover enough of
23:17
a range of microclimates it didn't get
23:19
enough data just from that north aspect
23:21
to give us a good estimate of the
23:24
flowering response and then if we look
23:27
at high elevations only or low
23:28
elevations only again we see this where
23:33
the high elevation is not significant to
23:35
get a good estimate the low elevations
23:37
did an okay job but that spread on the
23:39
standard error is pretty large and then

23:42
if we only looked at two years of data
23:44
just 2014 and 2015 it's a significant
23:49
estimate but that standard error is very
23:52
large compared to our original model
23:53
which incorporates 2014 2015 and 2016 so
23:58
we did that same kind of sub setting for
24:01
leaf out response and in this case again
24:04
looking at just lowbush blueberry on the
24:09
whole the complete model was I had a
24:13
regression coefficient of negative 4.3
24:15
or it's advancing 4.3 days for each
24:18
degree Celsius when we subset the
24:21
mountains we actually have
24:23
a pretty nice estimate across the board
24:26
for leaf out and I think that's because
24:29
we have slightly more leaf out data than
24:32
flowering data because every plant that
24:35
we monitored was weeping out but not
24:38
every plant that leaf out produces
24:40
flowers when we look at the north aspect
24:44
and the south aspect and break those
24:46
down we still get significant models
24:48
that you can see that they differ so the

24:51
north aspect is kind of under estimating
24:54
that change in leaf out response and the
24:57
south aspect only overestimates that
24:59
response and you see that same split
25:02
with high elevations and low elevations
25:04
where with just the high elevation data
25:07
on you get an underestimation and in the
25:10
low elevations overestimate that word
25:13
responsibly fast and if we only have two
25:15
years of data we don't have a
25:16
significant model at all for our beef
25:20
out response we really need those three
25:21
years of data to get a good handle on
25:23
how we felt is changing in response to
25:26
temperature so the main conclusions from
25:33
this hiking and observational transect
25:37
approach was that we have a leaf out and
25:41
flowering phenology that's responsive to
25:43
temperature across these environmental
25:45
gradients I'm here in Acadia and the
25:48
shift in days per degree Celsius is
25:51
smaller than in Concord Massachusetts so
25:53
they're advancing just like they are in

25:56
Concord but they're not advancing as
25:57
much and that's even on a species by
26:00
species level so the same species
26:02
growing in Concord needs to be shifting
26:05
it's flowering or leaf out more
26:07
dramatically than it on Mount Desert
26:10
Island and we recommend monitoring
26:13
strategies going forward that focus on
26:15
Cadillac or at least continue to include
26:17
Cadillac on southern aspects and
26:20
definitely more years we want to keep
26:22
monitoring these plants in Acadia
26:27
National Park into the future and I'll
26:29
talk I think at the end a little bit
26:30
more about our plans for that so the
26:34
second half of this talk is about
26:36
experimental gardens
26:37
and with this I wanted to ask or answer
26:39
the question what's driving population
26:43
differences and without responses within
26:45
Acadia National Park because as we were
26:48
doing the hiking to monitor plants
26:51
across three mountains in Acadia it was

26:53
really obvious that there are population
26:55
level differences in phenology um a lot
27:00
of species especially those nine common
27:02
species that I just showed you grow
27:04
across an entire environmental gradient
27:06
and they leaf out and flower at
27:08
different times
27:09
um at different places on those
27:12
mountains so is this a population level
27:16
genetic difference are the plants on top
27:19
of Cadillac the sheep's floor on topic
27:21
Alec just genetically different from the
27:23
sheep's floral at the base of Cadillac
27:25
or is it just a simple response to local
27:29
environment where it's just colder on
27:31
the summit and it's warmer in another
27:33
place and the the microclimate is
27:36
driving the timing of leaf and flower
27:40
and there's some good reasons for either
27:45
hypothesis so population level
27:49
differences could be an adaptation if
27:52
you are a plant that's growing in a
27:54
harsh and unpredictable environment like

27:56
the summit of a mountain because you
27:58
might be more likely to experience a
28:00
late season frost which means that you
28:02
might be more reluctant to start leasing
28:05
out or flowering at the first sign of
28:07
warmth because you know it could be kind
28:09
of a false start um and so you might
28:12
have some kind of local adaptation to be
28:15
more cautious whereas plants and lower
28:17
elevations especially in areas where
28:20
they're maybe not as exposed to things
28:23
like wind or ice storms you can have
28:26
that exact same species but it's
28:29
predisposed to leaf out or flower as
28:31
soon as possible so I can start growing
28:34
and reproducing and accumulating energy
28:37
because we know and mean everything has
28:39
a pretty short growing season so you
28:41
want to extend that growing season as
28:43
much as you can and so if you have
28:45
trade-off of do you want to extend the
28:49
growing season and get started as early
28:50
as

28:51
well or are you nervous about elite
28:53
season Frost different populations might
28:56
weigh those so straight off differently
28:59
and that was a huge
29:02
just answer for more fising of plants
29:09
but I think that it really drives home
29:12
the question of why there might be local
29:14
adaptations so to get at that question I
29:17
put together a common garden experiment
29:19
and common Gardens are pretty classic
29:22
experimental design where you transplant
29:26
plants to different locations and so um
29:30
we had three gardens there was a garden
29:33
at the summit the mid elevation and the
29:35
low elevation on Cadillac this is off of
29:37
the Auto Road and we filled them with
29:40
plants from those three elevations so if
29:42
you imagine that my beautiful drawings
29:44
here are all sheeps Laurel and the
29:46
purple shoots Laurel are the summit
29:48
population we put purple summit jeeps
29:51
Laurel into all three gardens and the
29:54
green sheep floral are the mid elevation

29:56
garden are the mid elevation sheep
29:58
sloths are and we put green
29:59
mid-elevation shoots Laurel into all
30:02
three gardens and we did the same with
30:04
the orange low elevation shoots Laurel
30:07
so within any one of these gardens if we
30:10
looked at the low elevation garden those
30:12
those plants are all experiencing the
30:14
same local microclimate so if they all
30:18
leaf out at the same time regardless of
30:21
their source population then you know
30:24
it's the local environment that's
30:25
driving that leaf out but if within one
30:29
of those gardens at the low elevation
30:30
you have without occurring at different
30:32
time all three of those plants are
30:34
experiencing the same local climate but
30:36
they're responding to it differently
30:38
based on whatever local adaptation they
30:41
had from their source population so this
30:46
is a nice photo montage of how we
30:49
actually did the garden building and
30:51
construction I worked with Friends of

30:53
Acadia volunteers who were incredibly
30:55
generous with their time and their
30:57
skills and we were able to put these
31:00
gardens together over a two-week period
31:02
in the fall of 2013
31:05
um and so we cleared these sites one is
31:11
at the basis Cadillac ones at the mid
31:13
elevation around one of the pull outs
31:15
and one is at the summit of Cadillac and
31:18
then we were able to dig out plants from
31:22
each of those three sites and plant them
31:25
into the gardens so each garden has
31:27
sheeps Laurel from all three elevations
31:29
lowbush blueberry from all three
31:31
elevations and three to cinquefoil from
31:34
all three elevations and we also tagged
31:36
those three species around the gardens
31:39
that were not transplanted to see how
31:42
local plants in the same local
31:45
environment as the gardens but without
31:47
the potential trauma of being
31:49
transplanted would respond on to the
31:53
local environment in terms of their

31:56
wiithout and we actually did monitor
31:58
leaf out and flowering over 2014 2015
32:02
and 2016 but not enough of the
32:05
individuals in the gardens flowered for
32:08
us to do a statistical analysis of
32:10
flowering so this is really focused in
32:12
on leaf out phenology and so our
32:15
hypothesis that population level
32:18
adaptations and phenology would exist
32:20
across cadillac's elevation gradient if
32:23
that hypothesis was true we would expect
32:26
the source population highlighted in
32:27
yellow to be really important and so in
32:31
this um chart I have the three species
32:36
the top one is chief Laurel then there's
32:39
lowbush blueberry and then three to
32:41
stink soil and then I along the top row
32:46
I have the different factors that could
32:48
be driving leaf out phenology so the
32:51
garden site that's the local environment
32:53
highlighted in orange year which is
32:56
actually also a good proxy for a local
32:58
environment because from year to year

32:59
the environment will shift unchanged we
33:03
we know that there are some really warm
33:04
ears and some really cold years and and
33:06
weird years like this year where there's
33:08
winter for a long time and then all of a
33:10
sudden it's summer and we have the
33:13
source population and then the last
33:15
three columns represent interaction
33:18
effects
33:18
where there's some kind of interaction
33:20
between the Year and the source
33:22
population or the site of the garden and
33:25
the year or the site and the source
33:28
population and so our analysis was to
33:31
look species by species at which of
33:32
these different factors was most
33:35
important in driving the date of leaf
33:37
out and so here's our result the stars
33:41
represent the factors that were
33:44
significant in individual species level
33:48
we found and the three stars show things
33:52
that are really significant so across
33:54
the board for all three species the

33:56
garden site in the year those two
33:58
factors that are related to local
34:00
climate were very important source
34:03
population on its own was only
34:05
significant for lowbush blueberry um so
34:10
there there's evidence that there's
34:11
local adaptation but it's not as
34:13
important as the garden site the local
34:16
environment I'm for she floral and for
34:19
three to cinquefoil that um source
34:23
population is important as an
34:25
interaction effect so it either
34:26
interacts with the site or with the year
34:29
in the case of she's floral and so there
34:32
is again evidence that there is
34:33
something happening at the source that
34:37
that local adaptation from whatever
34:39
source it came from but it's just not as
34:43
important and not as consistent as the
34:46
local environment so the local
34:47
environment is really driving that leaf
34:50
out phenology for all three species and
34:52
this is actually kind of good news

34:54
because from other studies we've seen
34:56
that plants that can shift their
34:58
phenology in response to different
35:02
temperature cues actually tend to do
35:05
better have better have higher fitness
35:07
and are less likely to go locally
35:10
extinct then species that can't do that
35:13
and so showing that all three
35:16
populations of these species can shift
35:20
their flower or shifts are their leaf
35:23
out time in response to different
35:24
climates shows that they might be more
35:28
resilient to climate change in the
35:29
future
35:31
than we might have thought so the summit
35:35
populations of these three species will
35:37
be able to adapt to a warmer future
35:39
because if you think about it this
35:40
experiment is also kind of a low-tech
35:43
warming experiment so we didn't have to
35:45
bring out heat lamps or do fancy
35:48
shoveling around our site we basically
35:50
just took plants from the summit and put

35:53
them in the mid elevation and the low
35:54
elevation site and those sites were
35:56
warmer than the summit's so we did a
35:58
low-tech warming experiment and found
36:01
that these plants were able to respond
36:03
pretty well and we had very low
36:05
mortality across the board so not only
36:07
could they survive in the warmer
36:09
environment but they seemed to also be
36:11
able to shift their leaf out to
36:12
accommodate that warmer environment so
36:16
we have leaf out phenology cued by local
36:18
Mike requirement regardless of the
36:20
source population and these population
36:23
level adaptations and phenology are just
36:25
not important on Cadillac Mountain for
36:27
these three species and our high
36:29
elevation population so summit
36:31
populations didn't display reduce
36:33
plasticity or the the inability to shift
36:37
their phenology compared to low
36:39
elevation populations
36:41
that's an interesting finding because in

36:43
other places where they've done common
36:46
garden experiments like this in the Alps
36:48
and the Pyrenees in the Rockies really
36:50
big mountains with really large
36:51
elevation gradients that's a pretty
36:54
common result to see high elevation
36:58
populations have less of a response to
37:02
warming than low elevation populations
37:04
and here we showed that across a really
37:06
compressed environmental gradient in
37:08
Cadillac we just don't see that hmm
37:11
so perhaps there's enough genetic mixing
37:14
across these sites you know it's not
37:16
that far from the base of Cadillac to
37:18
the topic Cadillac a pollinator could
37:20
probably make it that far they're not
37:21
getting they're not isolated enough to
37:23
develop some kind of genetic adaptation
37:28
so overall we have these ridge transects
37:31
on a desert island and demonstrating
37:33
advancing plant phenology and response
37:36
to spring temperatures in Maine and the
37:39
phenological responses in Maine match

37:41
the direction but not the magnitude
37:43
recorded in southern
37:45
so in Concord Massachusetts they're
37:47
advancing at a much faster rate and set
37:51
conditions our moat the most important
37:53
factor cuing leaf out on cadillac
37:55
mountain for our three species ships
37:58
laurel lowbush blueberry and three two
38:00
cinquefoil so those are the big
38:01
conclusions from these these two studies
38:04
um I just want to point out that I'm
38:07
still working in a KD a National Park
38:09
and I'm actually still working with some
38:10
thorough data um so I'd be happy to
38:13
answer any questions about this um I
38:15
have one project that's actually looking
38:18
back at that conquer dataset to look at
38:20
changes in leaf out x and changes in
38:23
flowering time since the night yeah 19th
38:25
century um where we show that leaf out
38:28
is actually responding faster um than
38:32
flowering times which means that the
38:33
canopy is closing um earlier on

38:37
understory species that rely on having a
38:42
high light environment before on the
38:45
canopy closes so um if the understory
38:50
species are not keeping up with their
38:52
phenology they're actually losing on the
38:55
timing of that that light environment so
39:00
they're getting less light in the spring
39:01
which could affect their ability to take
39:03
up carbon or to reproduce and I'm also
39:07
continuing some work in Acadia National
39:09
Park with a picture of Sargent mountain
39:10
pond which I chord in September 2017 to
39:16
look at pollen captured in the lake
39:19
sediments there to look at what's been
39:21
happening around Sargent on pond
39:23
since glaciers retreated 15 16 thousand
39:27
years ago um and so I haven't actually
39:29
looked at the pollen captured in that
39:31
core yet but hopefully soon I'll be able
39:34
to tell you about how vegetation and
39:36
communities around Sargent mountain pond
39:38
have changed over the last fifteen
39:40
thousand years so that's that I just

39:43
like to acknowledge some of the amazing
39:45
people I worked with before I jump into
39:47
questions um the first photo is my lab
39:50
mates
39:51
Amanda gallon at myself and Lucy this
39:54
who are all members of the Premack lab
39:56
they came up to me and to help out with
39:58
some fieldwork
39:59
um and they were just really excellent
40:01
people to have around when I was working
40:03
in Boston then abe miller wrestling the
40:06
science coordinator at Acadia National
40:07
Park he was on my dissertation committee
40:10
and was just a really invaluable
40:12
resource was doing work in Acadia
40:14
National Park and then in the last photo
40:16
richard Premack my adviser is hiding
40:19
behind lucy and he was an excellent
40:22
adviser at Boston University
40:24
I also have three undergrads who did a
40:27
lot of work on these projects
40:29
um but didn't take any beautiful
40:32
pictures with me or I didn't fail to

40:34
take pictures of them Pollock's coffee
40:36
are worse than the gardens the very
40:38
first year that the gardens were set up
40:40
so he was the real guinea pig and did a
40:42
wonderful job monitoring those gardens
40:44
um and then I worked with Ella Samuel
40:48
and Natasha Krell from college of the
40:50
Atlantic in 2015 and Ella Samuel came
40:53
back in 2016 and they worked on both the
40:55
gardens and the transect it was really
40:57
wonderful to work with them across the
40:59
bottom I have funders who helped to fund
41:02
this research from the Park Service
41:04
goethe-institut National Science
41:05
Foundation New England botanical club
41:08
and the Waterman fund and none of this
41:10
would be possible without those
41:12
resources and their support so thank you
41:15
very much and happy to to talk more
41:20
awesome thank you so much Caitlin that
41:22
was a really wonderful presentation with
41:26
lots of really beautiful photos and
41:28
great imagery and figures and everything

41:30
so I really appreciate you sharing that
41:32
with us it's great to see all that
41:34
research coming together yeah just so
41:38
everyone who's tuning in a quick
41:41
reminder if you move your cursor around
41:43
on your window that you're viewing
41:46
through zoom you should have a little
41:48
menu at the bottom and if you click on
41:51
the chat icon then you should have a
41:54
little box that you can type in a
41:56
message either address to everyone or
41:59
you can send it to me Elizabeth and
42:02
start filling in your questions there
42:04
and I'll read them out as they pop up in
42:07
the chat box while we wait
42:12
or any questions to come in Caitlyn I
42:14
actually have a question for you and say
42:18
I missed that before I can um I can
42:25
either go back let's see if that will
42:27
work
42:27
I can try to get back to these figures
42:33
but I also have the regression
42:38
coefficients for this here we go that's

42:40
what we thought
42:41
um so with leaf out um
42:45
the Canada Mayflower was leasing out 2.5
42:49
days earlier per degree Celsius and that
42:53
which color is that one I'm not sure I'm
43:01
gonna be I don't have the the legend um
43:03
on yeah I don't have the legend on this
43:10
figure but I have the legend on the
43:12
figure so this paper is actually in
43:14
review right now at ecosphere and I'll
43:16
send out everything as it becomes
43:21
published two signs of the seasons
43:23
um but will actually wear one of the
43:26
reviews had us mixing up this figure a
43:28
little bit making it easier to read so
43:30
um sorry I can't point out exact colors
43:33
on it before the flash data flowering I
43:37
can say that Canada Mayflower was not
43:43
significant in this case so um the trend
43:46
for Canada Mayflower is that it was
43:48
blooming earlier in warmer years um but
43:52
it was not a significant linear
43:55
regression with the data that we had and

43:58
I think part of this especially after
44:01
doing the analysis looking at lowbush
44:05
blueberry under different monitoring
44:06
strategies I think part of that is just
44:08
the UM the reduced number of data points
44:13
especially if we look at our mean spring
44:15
temperatures here from 0 to 3.5 is not a
44:19
huge spread um with the concord data set
44:22
second actually
44:25
kind of split back to I'm because I had
44:29
so many years across such a huge range
44:33
from the 1850s through the 2000 there
44:37
means furring temperature spread grows
44:39
from 4 degrees Celsius to 11 degrees
44:41
Celsius so they're covering a much wider
44:43
range of spring temperatures and at one
44:46
point um one of my lab mates told me
44:49
that I should rename my fuses to be um
44:53
phenology and Acadia National Park over
44:55
for normal years because I started
44:57
collecting this data after 2012 so I
45:00
missed the really early crazy warm year
45:03
and started collecting data in 2013 and

45:06
when I looked at the temperature data
45:08
which I had from 2014 2015 and 2016 on
45:12
when I looked at that temperature data
45:14
for March and April it's actually pretty
45:16
similar to each other so even though
45:18
2015 had that weird snowpocalypse and it
45:21
was there was still snow on the ground
45:22
in Acadia when I started my work on once
45:26
that snow melted everything just kind of
45:28
went back on track in terms of being a
45:31
pretty normal year and so the mean
45:34
spring temperatures were not that
45:37
different from other from the two other
45:40
years which is why we need to collect
45:42
more data do you think that there's
45:46
other environmental conditions that are
45:49
playing a role and the difference
45:50
between MDI and Concord like maybe like
45:53
precipitation and last frost date and
45:55
those kind of things like how do you how
45:58
do you think about those kind of things
45:59
as well and how they may play a role
46:01
yeah so I think I'm being a maritime

46:06
climate where it's yeah I think that
46:11
having
46:15
guard as a kind of sister site in some
46:19
ways is nice there's a lot of overlap
46:21
there's about 300 species of plants that
46:24
are in both locations but they're both
46:26
very different places Concord has had on
46:29
the urban heat island effect from being
46:34
a Boston suburb just really kind of jack
46:36
up the temperature in a way that we
46:38
don't experience on Manus Island so are
46:40
our temperatures are warmer than they
46:44
were in the 19th century but they're not
46:47
dramatically as as much or it hasn't
46:52
changed as much as in Concord
46:54
Massachusetts o conquerer it's kind of
46:56
like a canary in a coal mine in terms of
46:59
like getting an example of what rapid
47:05
climate change looks like from just the
47:08
urban heat island effect so I think
47:12
there's there's a little bit of that
47:14
where Concord has experienced more
47:16
warming than Mount Desert Island and I

47:19
think the climate is definitely
47:20
different being inland versus being on
47:23
the coast Concord is actually pretty
47:27
well conserved landscape in a lot of
47:29
ways I think something like two-thirds
47:32
of the the land in Concord is under some
47:35
kind of protection but there's still a
47:38
lot of development pressure in Concord
47:41
so that means that a lot of the the
47:45
plants that Thoreau was looking at those
47:48
populations have declined in abundance
47:51
some of them have gone extinct which
47:53
also might be affecting what we see in
47:56
terms of the phenology because what's
47:58
conquered and we did this as well in on
48:01
MDI we were looking at the date of first
48:03
flower and first leaf out and that's in
48:06
part just a relic of how 19th century
48:09
naturalist were doing it because those
48:11
were the things they got excited about
48:12
and they didn't have the systematic peak
48:15
flowering date or counting in
48:18
fluorescence that could allow a metric

48:21
that wouldn't be as skewed by the
48:24
abundance of a species but
48:29
yeah I think there's probably a lot of
48:32
reasons why Concord is different from
48:35
Mount Desert Island and some of them we
48:37
could try to tease apart with metrics
48:39
like looking at precipitation and
48:42
looking at things like growing degree
48:44
days instead of mean spring temperatures
48:48
and really getting into some of the
48:50
nitty-gritty meteorological stuff but
48:53
some of the things I think might be much
48:54
harder to resolve just in terms of
48:58
Congress history and the fact that
49:03
conquer the conquered data set is just
49:04
bigger and older and based on a much
49:07
longer time span that covers a wider
49:10
range of temperature or spring
49:13
temperature experiences is Acadia and
49:20
the research that they're doing or is
49:22
just the kind of planning and continued
49:26
monitoring that they do there do you
49:28
have a sense of like how they may be

49:31
able to use the outcomes of your
49:34
research yeah so we've started talking
49:38
about using phenology as a trait in
49:42
climate change vulnerability assessments
49:44
and so of the nine species that we
49:47
looked at there was one species
49:49
starflower that didn't have a
49:51
significant relationship between leaf
49:54
out or flowering and the in spring
49:56
temperature and that might might be a
49:58
sign that it's less responsive to
50:01
changes in temperature and might be more
50:03
vulnerable to climate change than some
50:05
of the other species which had at least
50:09
one Fino phase that was responsive to
50:12
temperature and so starting to use that
50:15
data in terms of building up a database
50:18
of of phenological traits um we've also
50:22
looked at on building this into their
50:26
phenology trails which have been really
50:29
active in this on the student side of
50:31
Acadia and we want to bring that into
50:35
the MDI side potentially through

50:39
nature's notebook on the USA NP
50:42
an app or with I naturalist to get a
50:48
kind of cast a wider net on people
50:50
making observational records as a as a
50:56
hike um so that's kind of still in the
50:59
early planning stages in terms of
51:01
continuing this phenological monitoring
51:03
program right kind of on this not to
51:07
interrupt you I'm sorry yeah okay same
51:09
thought process so the coastal Maine
51:13
Botanical Gardens we as the seasons have
51:17
been working with them this year to
51:20
establish some long-term monitoring
51:22
sites in gardens and one of the species
51:25
that they're focusing on is lowbush
51:29
blueberries so um that may be that's an
51:32
area where there could be some
51:34
comparison with Acadia yeah that'd be
51:38
great
51:38
um the gardens I was about to say I've
51:42
actually been repurposed for more on
51:44
experimental studies with Nick sister
51:46
Kelly at UM

51:47
Dudek Institute where the the physical
51:52
gardens remain they're actually really
51:53
beautifully built and made out of cedar
51:56
so they're going to be there for a while
51:57
but they've taken the plants out
52:00
actually the the plants in the summit
52:02
garden were used in some of the summit
52:03
restoration on Cadillac was just kind of
52:05
cool to think about um but they're now
52:09
full of tree seedlings on both from
52:12
locally sourced within Acadia or with or
52:15
from the island and from more southern
52:18
regions to look at potential for managed
52:22
relocation and assisted migration sis
52:25
you have different tree species respond
52:28
to this range of climates and it's
52:31
actually expanded so that it's not just
52:32
the three Gardens on Cadillac there's
52:35
now a set of gardens at screw deck and
52:37
as I understand I think schools across
52:41
Maine are also building similar Gardens
52:44
to continue this common book garden
52:46
experiment across a huge geographical

52:49
area which would be really cool to see
52:51
what Nick signs with his studies
52:54
yeah that's really amazing
52:58
cool well um I don't see any other
53:03
questions coming in through the chat I
53:06
think
53:07
[Music]
53:09
Esperanza is that you signing in or yeah
53:12
I was just gonna say if there aren't any
53:14
other questions I would just thank you
53:18
again Katelyn this is really fascinating
53:20
work and it's happening right here in
53:22
Maine so we'll be sending this out you
53:25
know far and wide for people to be able
53:28
to to take a look at this research and I
53:33
hope to make some connections I've been
53:35
talking with we've been talking with
53:38
Acadia kuduk and about the you know the
53:42
new work that's going on and we have a
53:44
lot of data actually probably some of
53:47
the tree species and so forth so stay
53:50
tuned great that sounds awesome and I
53:54
mentioned that the the transect paper is

53:57
in review but the the Guardian paper is
53:59
actually about to be published so I will
54:01
send that out to you as soon as it comes
54:03
out in the american journal of botany
54:05
and both of these papers will be open
54:07
access that is another thing that i
54:09
should definitely thank the funders for
54:11
because it's huge that we're able to get
54:16
these i'm into academic journals but
54:19
also available so that anyone can read
54:21
them they're not going to be hidden
54:22
behind a payroll a paywall so I'll share
54:25
those those links as soon as they come
54:27
out and the the garden paper should be
54:29
out later this month
54:30
that's excellent thank you so much
54:32
that's gonna be a great time a great
54:34
resource to have I want to thank
54:37
everybody for participating and if
54:39
anything comes up I'm sure we could get
54:42
other questions to Kaitlyn if necessary
54:45
so happily thank you so much