

Dr. Caprio Reminisces on His Role in Phenology in the United States

Dr. Joseph Caprio initiated the first widespread phenology monitoring network in the United States, the lilac network while working at Montana State University. In January of 2010, Joseph's granddaughter, Charlene Shovic, conducted a series of interviews with him in Tucson, Arizona during which she spoke with her grandfather about his broad scientific career including his role in phenology monitoring. Following are excerpts of those interviews, focusing on his interest in phenology and his important role in the science of phenology. The USA-National Phenology Network can directly trace its heritage to the early work of Dr. Joseph Caprio.

Transcription and editing was provided by Dr. Kathryn Thomas, USA-NPN science associate. Text in brackets ([]) was added to aid reading flow. Deleted text is not indicated. Charlene Shovic's questions are indicated with the abbreviations CS and Joseph Caprio's response with JC.

CS: This is part two of my interview with my grandfather, Joseph Caprio and we are going to talk about his development of and path through phenology.

JC: The purple common lilac had become a very important part of my work over the years. Are you familiar with common purple lilac? They grow all over the west and they're a nice smelling plant and it grows and blooms every spring. I'll tell you why it had become an important part of my work. So here goes....

When I went to high school I would walk about half a mile and on the same block where I lived further down the street I was always pass Wayne Hornbee's driveway
The Hornbee's lived on the corner of Jones Avenue and Comstock Street. We lived on Comstock Street.

CS: What town is this and what year?

JC: In New Brunswick, New Jersey and the years had to do with the early 40's when I was in high school. Every time I would pass there in the spring I would always see this beautiful purple common lilac and smell the aroma from the lilac, a huge plant at the side of the driveway.

So I remember that very distinctly because every spring the plant would come out and have a beautiful abundant bloom. So that's what I remember initially as a lilac in my life.

When I went to Rutgers University for a MS degree specializing in agricultural meteorology or climatology I had a major professor by the name of Irving Beal. Dr. Irving Beal came to the United States in the early 40's from Austria; he was an Austrian. He initiated climate meteorological and climatological studies and created a department of meteorology at Rutgers University. He was an excellent speaker and he gave wonderful lectures. He was an interesting man.

There are many things I remember about him because I got to know him very well as a graduate student. I was the only graduate student at the time so we had a lot of interaction. After work sometimes I would walk to take a bus. He didn't have a car; a number of professors didn't have cars in those days. He would take a bus to his home. We would walk to the bus together on occasion. One thing I remember about Dr. Beal was that he smoked. He smoked so much that his glasses were hardly visible to look at; they became smoked. He had other attributes that were good [laughing].

Dr. Beal in his lectures covered climatology but he also mentioned the work in Europe. Europeans had done phenological work. Actually, the first phenology work was done in Sweden by Linnaeus, the famous botanist. Other work was done subsequent to the 1700's when he started his work on phenology. Dr. Beal mentioned this; they were part of my lecture notes. I can't give you details because my lecture notes are not available. I don't know where they are. I took very detailed lecture notes. Sometimes he would joke about my taking every word he said (laughing).

So now let's start going to the beginning of the phenology work that I did professionally.

CS: What initially attracted you to climatology and meteorology in your academic life?

JC: When I was in the 7th grade I was interested in meteorology already in those early years. As far back as I can remember I was interested. We had a workshop and I remember I built a wind vane out of wood. That's the first [of] the hands on kind of introduction. There were no classes in meteorology then but I did build a wind vane in woodwork class where they taught you how to do woodwork. That was 7th grade.

Then I went to the 8th grade and in the 8th grade the New York Times carried weather maps in the library; the library subscribed to the New York Times. I would always look at the weather maps.

When I took classes and I remember one class and across out the window was a barn with a wind vane. I kept more attention to the wind vane I think that I did to the professor to see how the wind was blowing [laughing].

CS: Even before 7th grade what drew you to meteorology? What prompted that interest?

JC: One of the main things is that I loved snow; I loved the sports of snow and I loved the snow; it was so beautiful.

I liked to see just what caused snow to fall, what was the sequence of wind direction and temperatures and so on that made it snow. That was an inspiration for me to become more interested in weather.

CS: Can you define phenology?

JC: If you go to a dictionary you get a very good description. It has to [with] the development of organisms, both plants and animals, in relation to the climatic environment, particularly the variation from year to year of a particular event in an organisms' life. Plants and animals vary in their time of development, like with plants when they bloom. Some years the bloom is early. Usually attributable to what people think of as a warm spring, they come in earlier. Or you get a very cold spring and they come in later. But that is just vaguely what is behind coming in early or late.

That's what I got into – trying to describe, particularly for plants, what causes the variation in the timing of the development.

CS: You mentioned you got two Bachelors and then a Masters. What were your two Bachelors and where did you receive them?

JC: A B.S. in meteorology from the California Institute of Technology and a B.S. in agricultural science from Rutgers University. My masters degree was in agricultural meteorological from Rutgers University.¹

I got the offer of a job at MSU (Montana State University). I was working at Riverside California at the University of California. I got the job offer in the fall of 1955. I was given the offer of the job without interviews. I started the job on November 1st 1955.

Dean Maurice Kelso was given the job of creating a great regional project for the whole western region in agricultural meteorology. There had been that kind of work going on to the east, mainly on the Great Plains, and the Midwest. They wanted to do the same kind of thing for the western states, the 11 western states.

No one in the faculty knew about climatology and meteorology very well, particularly agricultural meteorology. I think that was the basis for them offering me the job because I had a lot of experience in this area.

What should I do? I'm there and I'm an assistant professor and they wanted me to do work. Mainly I was going to teach too, and I had to determine what I was going to do for research. I was mainly employed for research.

I decided that I should do something more about learning about the climate of Montana, in particular the climate with respect to how plants develop. Agriculture is mainly plant growth and livestock in Montana, different crops and livestock. I thought maybe we could in some way get some indication from plants.

How can we get an indication from plants? I suggested to the horticultural people there, Homer Metcalf was one of the professors and Dr. Iverson was another. The two of them helped in this effort to think about what we can do about learning about plant climate.

¹ Although not mentioned here, Caprio received a Ph.D. in biometeorology from Utah State University while on the faculty at Montana State University.

They suggested the best plant to use would be the common purple lilac; this is where that came in. For a number of reasons, it's grown all over the state even in abandoned homesteads. A lot of homesteaders in Montana went there to obtain homesteads for free from the government in the early 1900's. Some of them were abandoned during the depression era and still the lilac would survive in the yards of these old homesteads; they were abundantly available. The horticulturalists suggested that maybe we could learn about the plant if we observe the phenology of the plant in different areas and understand how the different valleys are different for plant climate. Not the weather climate, not the temperature and precipitation, but how is the plant reacting in the different valleys.

So how you get people to report? I went to the weather bureau, the state climatologist at that time at Helena, and I proposed to him that we should try to understand this. He was very receptive and said we could get the climatological observers throughout the state to report to us on when the plant developed different stages of development. Richard D[?] was the state climatologist at the weather service at that time. He enlisted the cooperation and asked people, there were about 200 of so [associated with] the weather stations throughout the state and we had a lot of people who cooperated. Also the garden clubs were interested in cooperating through the horticultural group. I'm not sure exactly how many but we must have had more than 100 people who observed in that spring of 1956.

I got there in the fall of 1955 and in the spring of 1956 we initiated the statewide phenology survey. They reported on when the purple common lilac began to bloom and when it was peak bloom and when it ended its bloom. Those were the 3 phases that we observed. There may have been a bud phase in there too. We received the data by card. We sent them a little card and they put down the dates and they mailed them to us in my laboratory. We analyzed it; we put all the dates on a map and looked at it and saw how the different areas were different in plant climate. Some areas were early; some areas were late. [Where there was] earliness and lateness by a certain number of days between two different places, we could say that there were that many days of difference in plant climate between those two locations. That was the first phenology work I had done.

Then Dr. Kelso had to call together a meeting of representatives from all 11 western state's Agricultural Experimental Stations to initiate a regional climate effort covering the 11 western states. The reason all of them came together was to have each state cooperate in a regional effort in agricultural climatology and each state was to propose how they could contribute to an effort in their own way toward the regional project. We met there in the middle of January. By the way, those two days, the minimum temperature was -30 degrees.

CS: In Bozeman?

JC: In Bozeman. Some of them came from Arizona or New Mexico or warmer places, in California. So they got exposure to Bozeman's low temperatures during the winter. I proposed that we consider extending the Montana effort to the whole region.

CS: The Montana effort of the lilacs?

JC: The Montana effort of the lilacs. I showed them the results of our survey that previous year's spring. This was January 1957, the next winter. They thought that one effort that Montana could make to the regional effort would to be [to] extend the survey to the whole western part of the United States. Well in that meeting there was the Regional Climatologist for the whole western region, Marv Magnusen. Marv was very receptive. He wanted this to go through. He probably could get the cooperation of the weather service for all the western states. They were willing and cooperating by provided franked envelopes and providing cards and the addresses of all the people in the western United States; there must have been 3500 of them. We solicited all, [well] not all of them, some in big cities were not of interest to us. Most of the people who were climatological observers, the 3500 in the western United States, we sent out [to by] mail and the weather service covered all that cost. We got about a couple of thousand people who wanted to cooperate and report on the purple common lilac to us and report the same way by card by mail. Now they do it by computer and internet.

CS: Who helped you stuff all those envelopes?

JC: We had a crew. We had financial support to do it. So we did this the first year 1957, the spring of '57. All this mail came to our office, my laboratory; I had a big laboratory and an office.

From 1957-61 we accumulated five years of data, and from all these places with all these cards. We had methods of communicating by putting addressograph plates into a machine. The machine would kick out the address so it was done mechanically on the machine. After five years there was enough information to get a general view of how the climate for all the western states was developing, so we knew all over the west information we were able to get from that data.

The big problem at that time was to map the data. How you map information in such a mountainous area. So we segregated the data into about 150 different tiers. So all [data] from [an elevation] tier were put on one map; another tier, elevation tier, on another map. We analyzed each tier of elevation map separately. Then we brought it together with cross-sections of those isolines of equal development dates and we got cross sections. We developed detailed maps of the whole western United States of the average date when lilacs begin to bloom. We had a map for every hundred feet from sea level to 10,000 feet. So that all you had to know was the elevation and latitude and longitude of a given location, go to the map that was pertinent, the correct elevation map, and that would tell you the plant climate for that location.

We were able to determine for any place in the western United States the average date when the lilacs bloom, what the difference is between any two locations in plant climate date. That particular information, the way we analyzed it, and the results of the analysis were put into a publication which was call 'The Pattern of Climate in the Western United

States'. It was published in 1966² and it has become the very basic publication for phenology.

After we had operated for a few years people in the Midwest and the eastern part of the United States in regional projects of experiment stations said that they would do it too. So what we started in the west, was started in the Midwest and the eastern part of the United States and also Canada particularly Quebec. Quebec was very interested and they accumulated a lot of information there.

CS: You took the idea that you had heard about from that professor of yours who brought it from Austria, you took it to the western hemisphere.

JC: Well I'm exactly sure I don't have my notes but I'm quite sure he did mention that phenology was something they do in the European area and that was the beginning of how phenology may have started in Europe.

CS: And it made sense to you, which obviously why you started it up in Montana.

JC: It must have because when [I] started to work there I got the idea that maybe I could do that for Montana.

In 1967 we decided to actually provide the plants to the observer from nurseries. The horticulturalist decided that there [were] two species of honeysuckle that we could use. We sought the two because sometimes disease takes away one kind of plant. We picked two honeysuckle varieties and the genotypes of these plants provided to the observer from the nursery. The nursery happened to be in Iowa; most of them came from the Iowa nursery.

We solicited the help of people, again, of the climatological observatories who would like to receive the plant and grow it, irrigate it and send the information to us. So here we had another plant, a honeysuckle. They're genotypes, meaning there is no difference in genetic base. With the lilac there could have been some difference in the genotypes and some difference between two locations could be attributable to a little difference in their genetic behavior. By doing this we eliminated the variable of different genetic base.

The two honeysuckles we had – one was called 'Arnold Red'³ and the other was called 'Zabeli'⁴ - happened to bloom about the same time. And then there was no question about the difference between two locations. But with the lilac it didn't make much difference. Our analysis had so abundant data that [a] little deviation [due to genetic differences among] the general common purple [lilac] didn't make any difference in our analysis.

² Pattern of Plant development in the Western United States. Montana Agricultural Experiment Station Bulletin, No. 607, 42 pp. [Available from Montana State University Library, P.O. Box 173320, Bozeman, MT 59717.]

³ *Lonicera tatarica* 'Arnold Red'

⁴ *Lonicera koroklowii* 'Zabeli'

We accumulated a lot of data over many years at many locations for both the lilac and the honeysuckle, and over the years we analyzed what was causing variation at different locations from year to year. The major impact was temperature. But we saw that the intensity of the sun was also a factor. [Temperature] became an interacting factor in our algorithms to explain the difference between different years and the time of bloom, when they come early and when they come late.

Also from the mapping we understood more about how fast the plants progressed up in elevation, how fast they progressed from north to south, how the difference is between how long the bloom period is along the west coast and other places. Along the west coast it's so cool in the spring that they have a long lilac period. In the Midwest it's shorter, like 20 days in the Plains area, and maybe more than 30 days along the coast.

We could also see that it wasn't always that the plant progressed upward in elevation, in some places it advanced downward in elevation [such as] along the coast where the cold air comes in from the ocean and it is warmer above than below. Many things we learned about the regional pattern of how the plants developed. We did many analyses; some of them were published. We learned a great deal about the pattern of the developments throughout the west. We [could] determine for any spot in the western United States the average date when lilacs bloom or the difference between two locations which is an indication that the climate differs between two locations as far as plant development is concerned.

CS: How did it feel to come up with this and see the data?

JC: It was an adventure. It was a discovery. Just like Columbus discovered America. It was a discovery. As a matter of fact, all this stuff I had been doing is many discoveries. So it made things interesting from day to day, and what we would find.

I said that we looked at the lilac and honeysuckle, and it so happens that the progression of the lilac is such that the honeysuckle had a different progression. We tried to understand why they did not progress the same northward, for example. We learned about why there's a difference between the two plants. For example, in Montana the lilac develops before the honeysuckle, but in the South and in California the honeysuckle develops before the lilac. So there's a switch in which plant develops first. This is known as phenological interception. There was one study in Europe, and a book put out by Dr. Schnelle, a German who wrote a book on phenology, and he discussed this thing interception in Europe. They look at different trees, for example, and see that some trees don't always bloom in the same sequence in different parts of Europe. He had done some work on what he called phenological interception, and we've done quite a lot of work also on this to explain why the two plants have a different sequence of development in different regions. It has to do with their need for winter chilling. The lilac has to have a certain amount of winter chilling before it starts responding to springtime warmth. If it doesn't get that chilling, then it doesn't respond to the warmth. The honeysuckle also requires some [but] it doesn't require as much chilling. So it completes its chilling

requirements before the lilac in the south, but it doesn't make much difference when you go up to Montana. So, that's why you have a difference.

We also had a regional project; part of the regional phenology work was for dryland winter wheat. Farmers would report to us, in this case. County agricultural agents found farmers who would tell us about the phenology of the dryland winter wheat in their area. We were able to relate the two so that we knew that the difference between lilac bloom and wheat occurred differently in different areas. So we had a pattern of when that occurred throughout the west[ern] dryland winter wheat.

I retired in July of 1993, and a professor in our department, volunteered to continue the work. But he lost interest after a couple of years and he just terminated the project. He didn't want the effort. He had other interests. So that was the end of the phenology work there. But, there was a professor down in La Jolla, California by the name of Dan Cayan, at the Scripps Institute of Oceanography in La Jolla. He heard about all the data we had and decided to make an effort with us to try to understand how the plant development was changing over time [and] to see how the climate was changing that might have caused the plant to come in earlier. Were the plants coming in earlier because it was getting warmer? So he, along with me and the help of others, analyzed all the data we had over those many years over the western region to see whether the plants were coming in earlier because of climate warming. The result of that was very important in a publication that came out in the American Meteorological Society⁵, kind of recent, like [2001]. It was widely accepted and required by people and they wanted to see the results of that analysis. The cover of the magazine for one month featured that study on earliness. The earliness was about 2 days early per decade over the period of the study.

CS: What was early?

JC: The 'lilac-begin bloom' time. When the lilacs begin to bloom had been coming in two days earlier every decade over the 4 decades that we were working with. So that was an indication, at that time, that the phenology and the ecology of the area are changing because of climate warming. That's the first one. There has been a lot of effort recently to understand more about the ecology and the implications of climate warming. But that was one of the first.

CS: So, two days for every decade. Did it increase, though, for the most recent decades? Has it been a steady two days over the course of the four decades? Or given that climate has exponentially increased in terms of temperature.

JC: We didn't have enough information to determine. We just had the linear impact over the period of about two days earlier. In 1984 I had noticed from data in my own laboratory that the plants seemed to be coming in earlier. I wrote up in a report that, in 1984, it seems like the plants were coming in earlier. At that time people weren't thinking

⁵ Cayan, D.R., S.A. Kammerdiener, M.D. Dettinger, J.M. Caprio, and D.H. Peterson. 2001. Changes in the onset of spring in the western United States. *Bulletin of the American Meteorological Society* 82(3):399-415.

of climate change much and we reported the indication that the plants were coming in earlier possibly due to climate change.

CS: So you noticed this for a long time.

JC: Yes; 1984. Other persons, Dan Cayan [and] the other people working with him there in the U. S. Geological Survey; he was connected with the U. S. Geological Survey. Also a fellow named Julio Betancourt with the U. S. Geological Survey, who has done a lot of ecological work, became very interested in the results of our study that showed the plants coming in earlier with time.

Through Julio's efforts, and Dan Cayan's efforts, and a person who picked up phenology during the time I was retired...his main Ph. D. dissertation was on phenology...a young man by the name of, his name doesn't come to me...but anyway, early he was with the University of San Francisco and he then got a job with the University of Wisconsin...Mark Schwartz is his name.

[Mark Schwartz], Cayan and Julio got together and convinced the National Science Foundation that this was important kind of work that needs to be done because our whole ecology - plants, animals, and all the wildlife - could be impacted by climate change. So the National Science Foundation supported a meeting here in Arizona. That was only about 4 years ago, maybe 5 years⁶. Also many agencies are interested, [the] U. S. Forest Service, and other agencies. These agencies each contributed money in support of this meeting called together to initiate a nationwide phenology effort. They wanted input from people who knew about phenology from Europe; we brought in people from Europe [and] from Canada. About 40 people attended the meeting here in Tucson. The National Science Foundation was the main [support] and these agencies contributed also and sent representatives to the meeting. It was held in the Westward Look Resort here in Tucson, northern part; a very nice resort.

For a week, from Monday through Friday, we met and discussed the possibility of creating a national phenology network. I'd been long retired, you know. At that time I had already been in Canada for a number of years. They called me to attend the meeting, and I came down by plane to attend as well. We considered what to do to create a national phenology program [as] they called it, from one side to the other [so that] all 48 states would be involved. The questions were what plants would be observed in different areas. Some leading people were there, leading ecologists in the country were there; still noted ecology people; people who are leaders in the field of ecology.

The U. S. Geological Survey said that they would be extremely interested in supporting this effort. The U. S. Geological Survey is a government agency, a very large government agency. They're responsible for such things as stream flow and that kind of thing. But they have a biological portion. Through that interest they decided that they would be the core center for the development [of the phenology program]. They would set up a

⁶ USA-NPN Implementation Workshop, August 22-26, 2005. Tucson, Arizona.
<http://www.usanpn.org/?q=npn-implementation-workshop-august-22-26-2005>

separate division in the U. S. Geological Survey to handle phenology work and that they would, along with the University of Arizona which was very interested, provide us with a place to meet, a place to establish the unit, a place where the work would be done. The U. S. Geological Survey would provide money and the personnel. So that was about a couple years ago; about 3 years ago that this happened. And now for 2 years the national effort has been going on centered here in Tucson at the University of Arizona.

Mickey⁷ and I went there last time we were here in Tucson, about almost 2 years ago to visit with them. Since then there's been development [and] they've been expanding. It's not only plant phenology, but it's also animal phenology, like deer and elk and birds of different kinds. How are these things being impacted and how are they changing, and what explains these changes, insofar as the possibility. The impetus of this has been climate change.

CS: Are there any suggestions or advise that you would give someone who's just starting in this field?

JC: You know things had changed so much since I retired [that] it'd be hard to do that. This fellow who picked up the phenology work after I retired or sometime just before I retired, Mark Schwartz, really was devoting himself completely, almost completely, to phenology after he got his Ph. D. degree. He has become very instrumental in [a] national organization called International Society of Biometeorology. He is now very instrumental in phenology and also in world-wide phenology. But I don't know what I could tell Mark Schwartz. He's probably doing things that I would be amazed to see. He has done some interesting work that I know of.

CS: Now, where do you see phenology's role in future?

JC: Phenology. You know there's a woman in Canada who has been doing phenology - a French name, isn't it - Elizabeth Beaubien. She's been doing Canadian [phenology] work, and I wonder why we don't cooperate together and get a survey of all that Canadian country. When I go down there to Tucson, I'm going to talk about that. Why should we stop at the border when we should go all the way up to Canada all the way up to the north? I'd be fascinating to have them be in part of this survey. As far as I know it hasn't happened. She was one of the representatives, by the way, at that meeting here in Tucson.

Where phenology is going to go, it's hard to say. It's just hard to say. I don't know, if the climate doesn't change, if it goes back and gets colder again, it probably will become less of an item of interest. So, if it continues to warm up quickly, it will probably become more important in the future. We can utilize the phenological data that's occurring to more rationally manage our environment, manage the plant and animal life. Now fish and wildlife, the management of fish and wildlife is very important. It would help the people who are involved with fish and wildlife; it would help to manage their efforts. Also forestry, for example, what's going to happen with the pine bark beetle? It's killing

⁷ Dr. Caprio's wife.

forests, extensive forests and it's attributable to warming of the climate. So they want this information to know how different species interact because one species in an ecological setting could affect another species.

So that would be my reply. I think it's going to be important if the climate changes. If it doesn't change it may become not so important.

CS: Is it true when Grandma says that you are the Father of Phenology?

JC: You know, a lot of people have done phenology in Europe. And actually the famous botanist Linnaeus established a network, I don't know, 20 observers or something, I think it was in Sweden. And I think, as far as phenology itself is concerned, I'm not the Father of it. I could maybe be considered the Father of Phenology in western United States. Or the United States if they want to think of it that way. But even in the United States, [there is] Leopold. Did you ever hear of the ecologist Leopold at the University of Wisconsin? He's the famous ecologist and he did a little bit of phenology work. But no one in the United States did extensive work the way I had done here with the network. So as far as America is concerned, I've done the most extensive work that anybody had done in the United States. So I don't know if you want to call it that or not, but certainly not world wide.

CS: How does it feel, reflecting and looking back, like you're doing it, all the different types of work that you've been involved in. What does it feel like looking back at all this?

JC: You know, most people when they retire from the University, they retire. That's the end of their work; that's the end of their research and that's typical. In my case, I took the work as visiting professor, visiting scientist in Canada to continue my efforts. And also from there it extended. The reason is because I had something to offer through my knowledge of the iterative Chi-Square method. So because of that I was able to continue with my discovery work, my scientific work for way beyond the time that I retired in 1993. I'm still doing it now. I'm grateful that I didn't just have to drop things off, and try to find my way doing other things because I was so interested in what I was doing.

Every study was an adventure, because I didn't know what we'd discover. It's like Marco Polo or other people who were discovering things, but they discovered different things than I discovered. But it makes life interesting to find things you discover. You wondered about if I can find out; I wondered why. If you could find out it'd be very interesting to know. That's the challenge of science and doing things in science.