***AGAINST ALL ODDS***
**EPISODE 7 – "NORMAL CURVES"**
**TRANSCRIPT**

FUNDER CREDITS

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INTRO

**Pardis Sabeti**
Hi, I'm Pardis Sabeti and this is *Against All Odds*, where we make statistics count.

Histograms are pretty much old hat by now. You know they're a great way to graph the distribution of all the sample values for one particular quantitative variable.

Size of Gala apples at one local orchard? Here's your histogram!

Math SAT scores for entering students at a state university? Here's your histogram!

Percent of senior citizens in the U.S. population over the decades? Here's your histogram!

To make it even easier to focus on general shapes, sometimes statisticians draw a smooth curve through a histogram. This can help us spot similarities in shapes – even when the histograms we're comparing don't necessarily have the same source or scale.

You might notice something about the smoothed histograms in our example. The apples and the test scores result in roughly the same shape curve – though of course the datasets are completely unrelated. This special shape is called a Normal curve – it's symmetric with one peak, what we call bell-shaped. The mean mu and the median are the same point, right here in the middle. Lots of distributions in the natural world exhibit this so-called normal curve shape – as we can see on a visit to Manomet Center for Conservation Sciences, located on the shore of Massachusetts.

> **Trevor Lloyd-Evans**
> This is sort of a center for migration; almost anything can be coming up our coast.

**Pardis Sabeti**
Since 1970 biologists here have been tracking migratory birds as they pass through every spring and fall. 50 mist nets spread out over the property, ensnare birds when they come down to rest or feed in this attractive seaside habitat. Researchers quickly work to disentangle the birds and head back to the lab to measure and record all the vital stats.

> **Manomet Volunteers**
> Wing is 61. Fat 5. Zero CP, Zero BP, 4 Molt, 3 Skull…

**Pardis Sabeti**
Each bird also gets banded… a little anklet that contains identifying info is placed on its leg, so anyone who catches this bird again – whether at Manomet or as far away as South America or the Arctic – can learn more about where it's traveled.

Over the decades, the scientists have banded thousands and thousands of birds and collected tons of data points before sending them back on their way.

> **Trevor Lloyd-Evans**
> Catbird…off you go.

**Pardis Sabeti**
Here's a histogram built from wing lengths of all the grey catbirds they've measured since 1970. And another for all the gray catbird weights. And take a look at one more, which tracks how many white-throated sparrows get banded each day of the fall migration season.

Recognize anything special here? We can draw a normal curve over all three examples. The bars of the histogram represent the actual sample data the researchers collect from the birds they capture.

The curve represents our idealized assumption of what the whole population of weights would look like for every catbird that passes through Manomet, whether captured or not. It's based on the actual data.

An important feature of any normal curve is the fact that it's completely defined by its mean, mu, and its standard deviation, sigma. If you change the mean, the whole curve just scootches along the *x*-axis. If you change the standard deviation, you're changing the distribution's spread, and the peak gets flatter and wider or taller and narrower.

The Manomet bird records allow scientists to build a comprehensive picture of how bird migration has changed since they first started collecting data.

> **Trevor Lloyd-Evans**
> We actually track it down to the number of nets that were open the number of hours, so we have a birds-per-net-per-hour figure. And by 1995 we were catching half as many birds as we were in 1970, so we saw a 50% drop over 30 years.

**Pardis Sabeti**
Much of that decrease in bird population can be chalked up to habitat degradation and loss. If there aren't good places for the birds to live, eat and breed, they won't survive.

What's unique about the Manomet record is that it lasts all the way through each migration season. That provides researchers with much more info than a commonly collected piece of data called 'first arrival.'

**Libby Ellwood**
Birders, birdwatchers, they go out each year and often what they're most interested in and what they record is the date that they see the first bird of a species each year. So first date is interesting and important, however it can be very variable with changing population sizes. So that's what makes these data from Manomet so valuable is that we also have mean arrival, which is less susceptible to changes in population size.

**Pardis Sabeti**
Check out these normal curves showing migration data for the Blackpoll Warbler. The *y*-axis measures the number of individual birds observed. In Year 1, many more birds were caught at Manomet, which you can see from the higher peak.

By Year 33, fewer birds were passing through. What's interesting is that while the mean stayed the same, the first bird now arrives later in the season. That's a function of the population shrinking.

Smaller populations are harder for researchers to keep tabs on because the individuals are comparatively few and far between.

**Libby Ellwood**
With a smaller population size it becomes increasingly difficult to see that first bird, so that's why we see it later.

**Pardis Sabeti**
Here are the curves for another species, the Eastern Towhee. Again, the *y*-axis describes the number of individual birds observed. You can see the population decreased for these guys too, based on the lower peak in Year 33. What's different here is that the first arrival was spotted at about the same time over the decades, and the mean of the distribution has shifted earlier.

If you only know the first arrival date, you wouldn't have a clue that the mean arrival has shifted. Something is affecting migration timing for this population as a whole – most likely climate change.

**Libby Ellwood**
If it's a warm year and plants leaf out and flower early, then maybe insects would also emerge early and then ideally the birds would arrive early so they could take advantage of the insects and the food sources that are available. / So if those events become out of sync, if the birds are not arriving earlier in a warmer spring / they could suffer as a consequence.

**Pardis Sabeti**
It's easier to make comparisons on the Eastern Towhee data if we convert each bell-shaped smoothed histogram into a Normal density curve. To do this, we change the scaling on the *y*-axis from a simple count of the number of birds observed, to relative frequency, or proportion.

With this new scale, the total area under the density curve is one. Even though these curves are based on different numbers of birds, the area under each density curve represents 100% of the birds in each sample.

Now we can compare the proportion of birds that arrived by a specific day for Year 1 and Year 33.

It's obvious the mean for Year 1, is later, with the whole curve moved along the horizontal axis to the right. The curve for Year 33 is a bit taller and pointier, because the data that year is less spread out, with a smaller standard deviation. And you can see that those first arrivals are happening at just about the same time. What's different between the two years is the proportion of birds that have arrived by a particular time. In Year 33 half of the birds had arrived within 48 days of the spring equinox, while in Year 1 only .23 or 23% of the birds had arrived by that time. In Year 1, it was another week until half the birds had arrived, at 55 days after the equinox.

Here are the density curves for the Blackpoll Warbler with its consistent mean over the years, and its later first arrivals. From the density curve we can compare the proportion of birds arriving by a certain day. Let's pick Day 56. In Year 1, the area under the curve is 0.10; meaning 10% of the birds had arrived by this date. In Year 33, the area under the curve is 0.04; meaning only 4% of the birds had made it. So the percentage of birds that used to arrive by day 56 is more than double what it is now. In both years, half the birds have arrived by Day 67. The only thing causing the observed later first arrival is that fewer birds are migrating – making it tougher for researchers to spot the rarer birds. Remember, it's the observed first arrival. A bird or two can easily sneak in under the radar, so to speak, unseen by researchers.

The scientists at Manomet say it's important to take into account population sizes when looking at migration times… especially if the only data available are those easily influenced first arrival dates. Fewer birds could mask the reality that while the first bird is being spotted at a consistent date, a far larger percentage of the population is arriving earlier. You don't want to base important conservation decisions on misleading data. Luckily things are looking up for some of those birds after the rough decades of the '80s and '90s.

**Trevor Lloyd-Evans**

The conservation policies, both at the national and international level, the fact that people are learning more about birds and preserving habitat in their backyards to go down to the smallest level, the people that are putting out birdfeeders in the winter; and so for a variety of reasons like those, we've found at least for the last 15 years that all bird populations are level. This does not mean that some are not declining, and those are the ones we should be concerned about. But it does also mean that some are increasing, and that is good news.

**Pardis Sabeti**
A nice silver lining for some of our feathered friends. See you next time, I'm Pardis Sabeti for *Against All Odds*.

PRODUCTION CREDITS

Host – Dr. Pardis Sabeti

Writer/Producer/Director – Maggie Villiger

Associate Producer – Katharine Duffy

Editors – Jared Morris
—Seth Bender

Director of Photography – Dan Lyons

Additional Camera – Ken Fraser

Sound Mix — Richard Bock

Animation – Jason Tierney

Title Animation – Jeremy Angier

Web + Interactive Developer – Matt Denault / Azility, Inc.

Website Designer – Dana Busch

Production Assistant – Kristopher Cain

Teleprompter – Sue Willard-Kiess

Hair/Makeup – Emily Damron

Additional Footage:

- Pond5/machineguncrew
- Pond5/trataka
- Pond5/tbmpvideo
- Pond5/moddeydhoo
- Pond5/sheyno
- Pond5/reelcontact

Music
DeWolfe Music Library

Based on the original Annenberg/CPB series *Against All Odds*,
Executive Producer Joe Blatt

Annenberg Learner Program Officer – Michele McLeod

Project Manager – Dr. Sol Garfunkel

Chief Content Advisor – Dr. Marsha Davis

Executive Producer – Graham Chedd

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