This presentation premiered at WaterSmart Innovations

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INNOVATIONS

Let’s Take It Outside
How Much Does Wind Effect Efficiency

The Intelligent Use of Water.™

LEADERSHIP • EDUCATION • PARTNERSHIPS • PRODUCTS

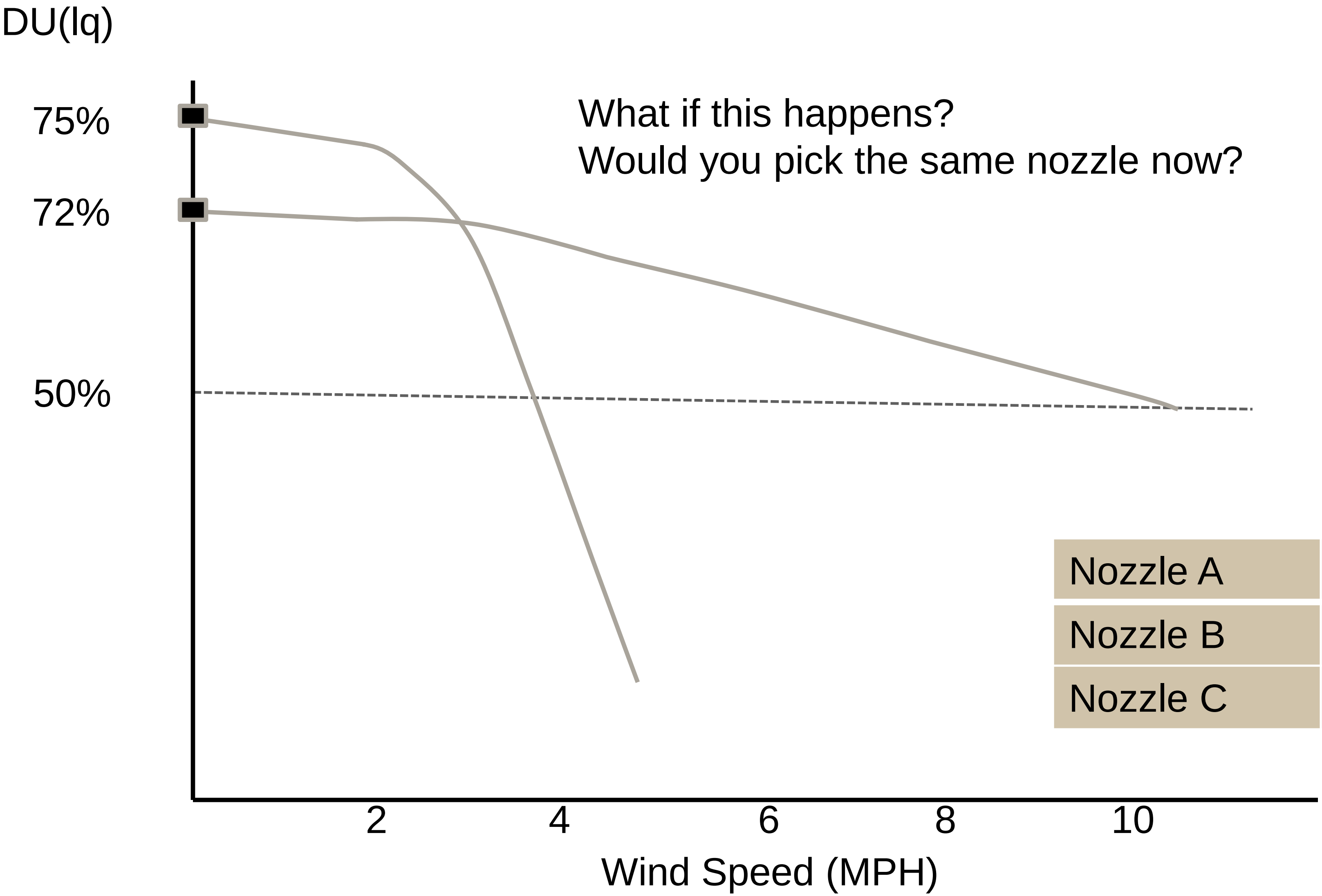
In 24 minutes and 13 seconds…

- **Show you why some of our most coveted single point metrics can be misleading us when it comes to water savings**

- **Show you some real data showing how product performs outdoors**

- **Explore a portion of a broader method for determining product's efficiency in the Real World!**

Always Question Single Data Metrics



What if this happens?
Would you pick the same nozzle now?

Nozzle A	75%
Nozzle B	72%
Nozzle C	72%

Initial Intention

- **Begin a series of “real world” tests to determine how products stand-up to these efficiency metrics when we try it outside in the real world**

- **The first variable we desired to understand is the effects of wind on typical “efficiency” metrics**
  - DU numbers are determined in a zero-wind building. What happens to distribution uniformity outside?

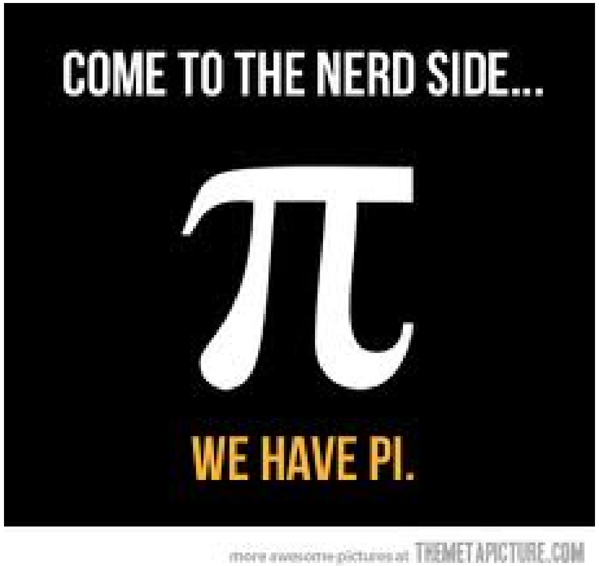
- **We are partnering with various third-parties to run independent studies and analyze the results to ensure scientific and rationale conclusions**
  - No “find data to support what we want you believe”

The University of Arizona

- **Independent testing was conducted at the University of Arizona to determine the effect of wind on nozzle efficiency**

- **The primary objective was to begin to paint a picture and determine how wind effects DU**

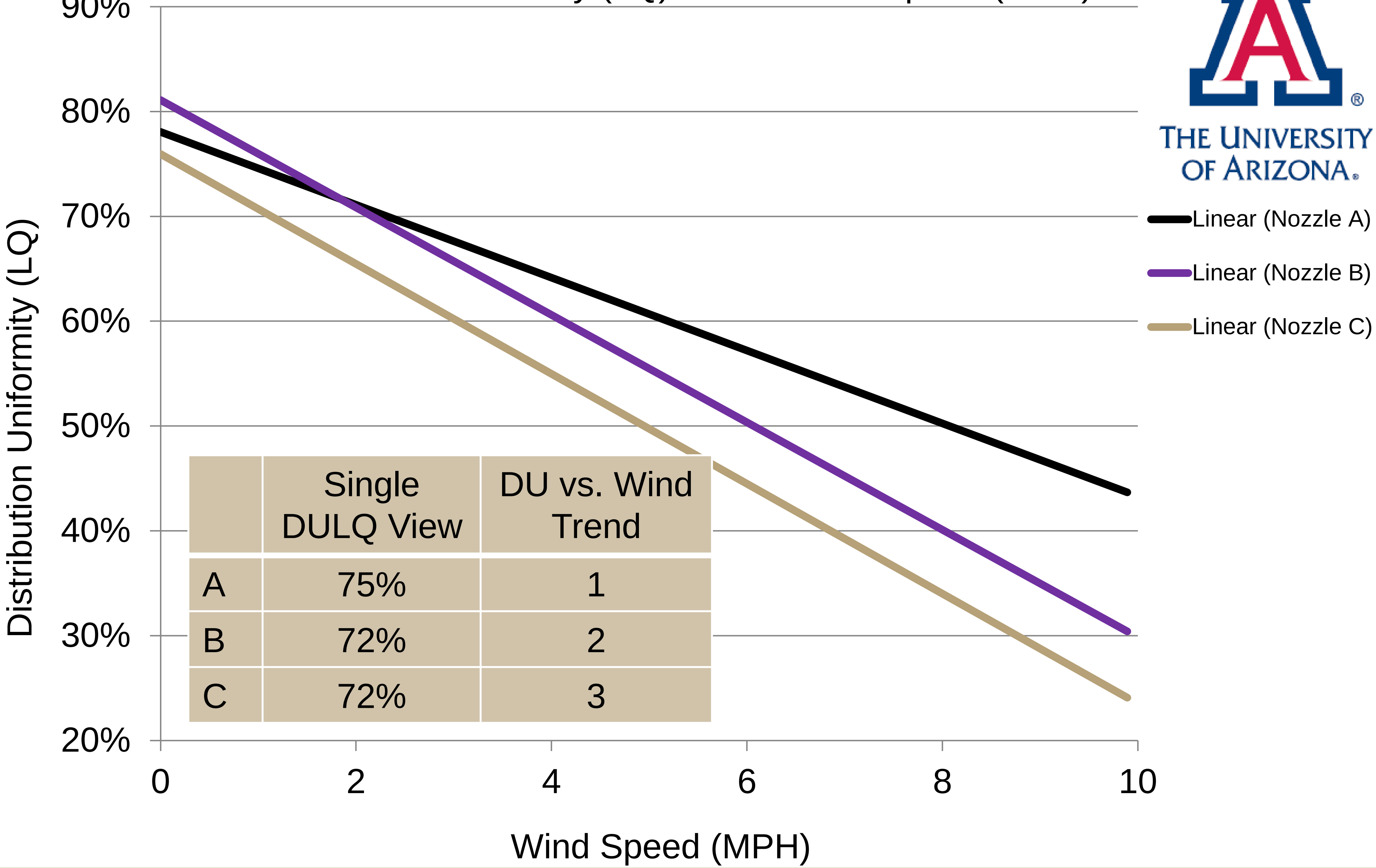
- **Secondary objective was to compare different nozzle's designs to each other**



more awesome pictures at THEMETAPICTURE.COM

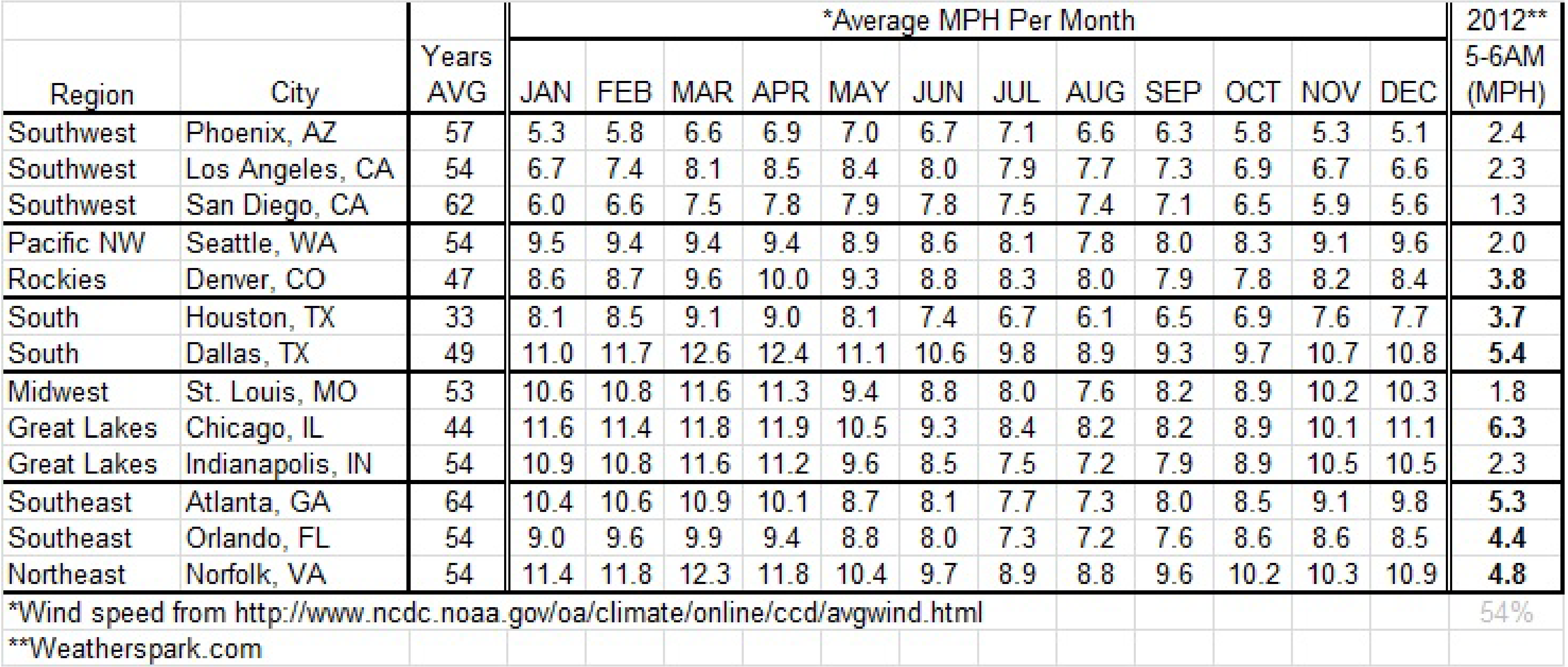
3 OUT OF 2
PEOPLE
HAVE
TROUBLE
WITH
FRACTIONS

Distribution Uniformity (LQ) versus Wind Speed (MPH)



	Single DULQ View	DU vs. Wind Trend
A	75%	1
B	72%	2
C	72%	3

Challenge Conventional Wisdom



			*Average MPH Per Month												2012**
Region	City	Years AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	5-6AM (MPH)
Southwest	Phoenix, AZ	57	5.3	5.8	6.6	6.9	7.0	6.7	7.1	6.6	6.3	5.8	5.3	5.1	2.4
Southwest	Los Angeles, CA	54	6.7	7.4	8.1	8.5	8.4	8.0	7.9	7.7	7.3	6.9	6.7	6.6	2.3
Southwest	San Diego, CA	62	6.0	6.6	7.5	7.8	7.9	7.8	7.5	7.4	7.1	6.5	5.9	5.6	1.3
Pacific NW	Seattle, WA	54	9.5	9.4	9.4	9.4	8.9	8.6	8.1	7.8	8.0	8.3	9.1	9.6	2.0
Rockies	Denver, CO	47	8.6	8.7	9.6	10.0	9.3	8.8	8.3	8.0	7.9	7.8	8.2	8.4	**3.8**
South	Houston, TX	33	8.1	8.5	9.1	9.0	8.1	7.4	6.7	6.1	6.5	6.9	7.6	7.7	**3.7**
South	Dallas, TX	49	11.0	11.7	12.6	12.4	11.1	10.6	9.8	8.9	9.3	9.7	10.7	10.8	**5.4**
Midwest	St. Louis, MO	53	10.6	10.8	11.6	11.3	9.4	8.8	8.0	7.6	8.2	8.9	10.2	10.3	1.8
Great Lakes	Chicago, IL	44	11.6	11.4	11.8	11.9	10.5	9.3	8.4	8.2	8.2	8.9	10.1	11.1	**6.3**
Great Lakes	Indianapolis, IN	54	10.9	10.8	11.6	11.2	9.6	8.5	7.5	7.2	7.9	8.9	10.5	10.5	2.3
Southeast	Atlanta, GA	64	10.4	10.6	10.9	10.1	8.7	8.1	7.7	7.3	8.0	8.5	9.1	9.8	**5.3**
Southeast	Orlando, FL	54	9.0	9.6	9.9	9.4	8.8	8.0	7.3	7.2	7.6	8.6	8.6	8.5	**4.4**
Northeast	Norfolk, VA	54	11.4	11.8	12.3	11.8	10.4	9.7	8.9	8.8	9.6	10.2	10.3	10.9	**4.8**
*Wind speed from http://www.ncdc.noaa.gov/oa/climate/online/ccd/avgwind.html															54%
**Weatherspark.com															

- **On average, most major cities experience greater than 4 MPH wind year-round**
- **Digging deeper into the data reveals, that the best practice of irrigating early in the morning still stands; however, many major cities have greater than 3 MPH wind 24-hours a day**

Keep Looking!

- **None of this research is new**
- **Much of this research has been done**
  - There is a great opportunity for someone to find and compile all the work into one body of understanding
- **A relevant example:**

Sprinkler Irrigation and Soil Moisture Uniformity

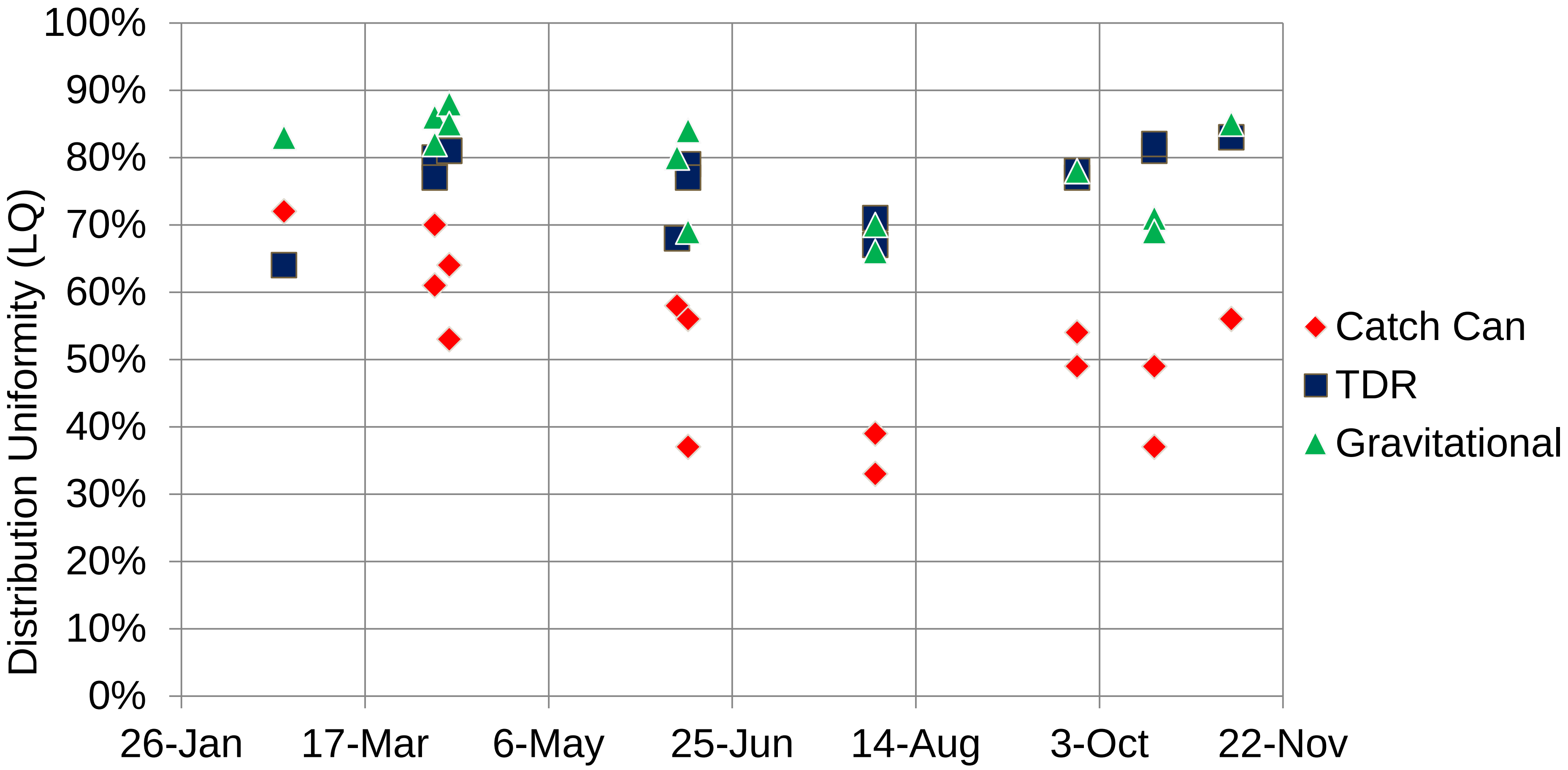
Michael D. Dukes, Melissa B. Haley, Stephen A Hanks

November, 2006

http://irrigationtoolbox.com/ReferenceDocuments/TechnicalPapers/IA/2006/038.pdf

UF UNIVERSITY of FLORIDA

Distribution Uniformity (LQ) Comparisons



This research suggests that even if a nozzle has a DU(lq) down to 50%, the result in the ground is still a DU(lq) over 70%! So, this means priority should be to get water in the target zone!

Analysis Definitions

- **Application Efficiency – The amount of water in the catch-cans divided by the total amount of water applied, as provided by the plot supply meter**
    - INTERPRETATION: Ideally, we want as much of the water supplied to end up in the target zone. Any amount that does not end up in the target zone was most likely lost through misting, evaporation or water pushed out of the zone by wind. As wind increases, it is expected that most of the water loss is due to pattern being pushed out of the target zone.

    - If water doesn’t make it into the target zone, does distribution uniformity really matter?

Application Efficiency (AE32) versus Wind Speed (MPH)

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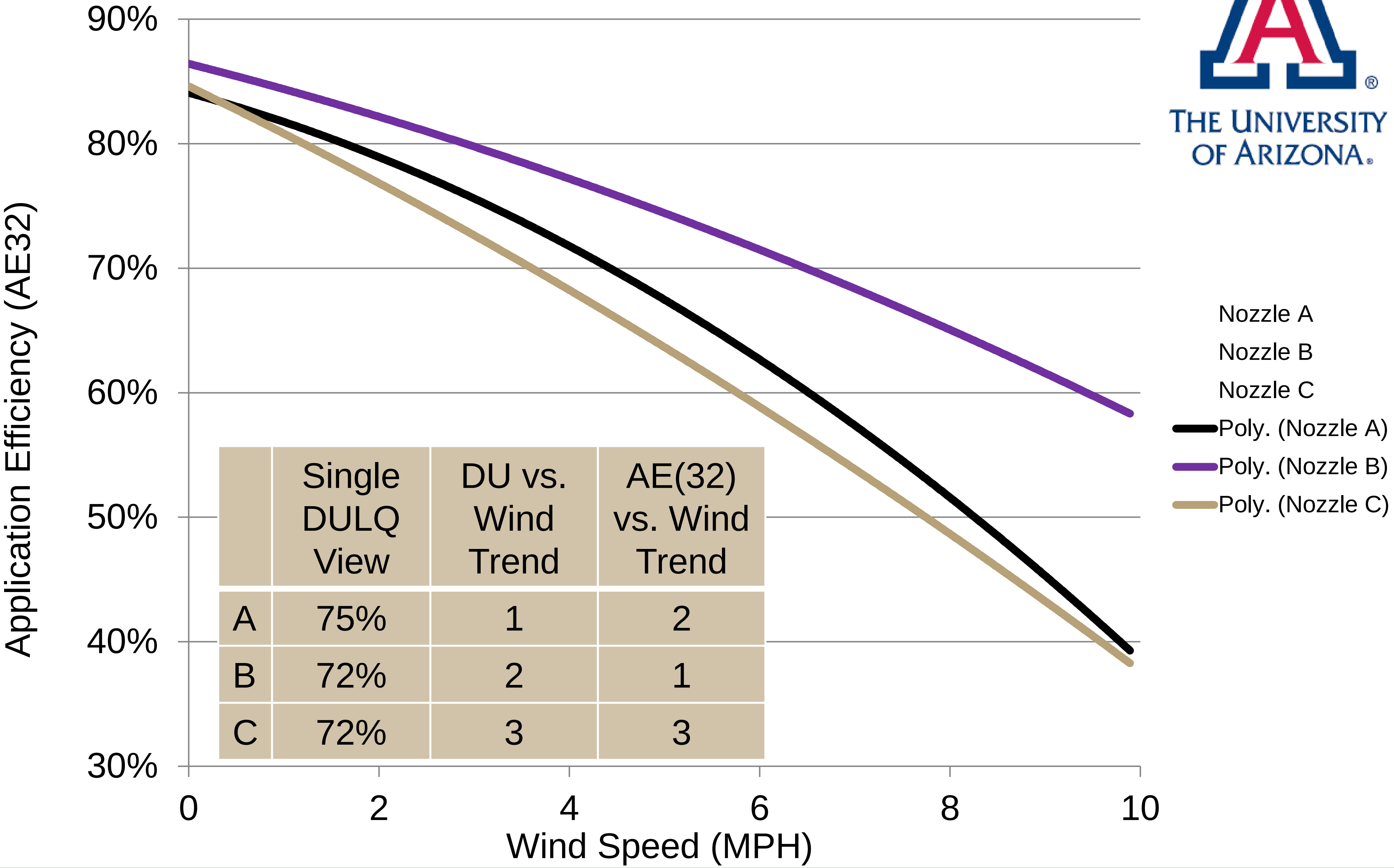
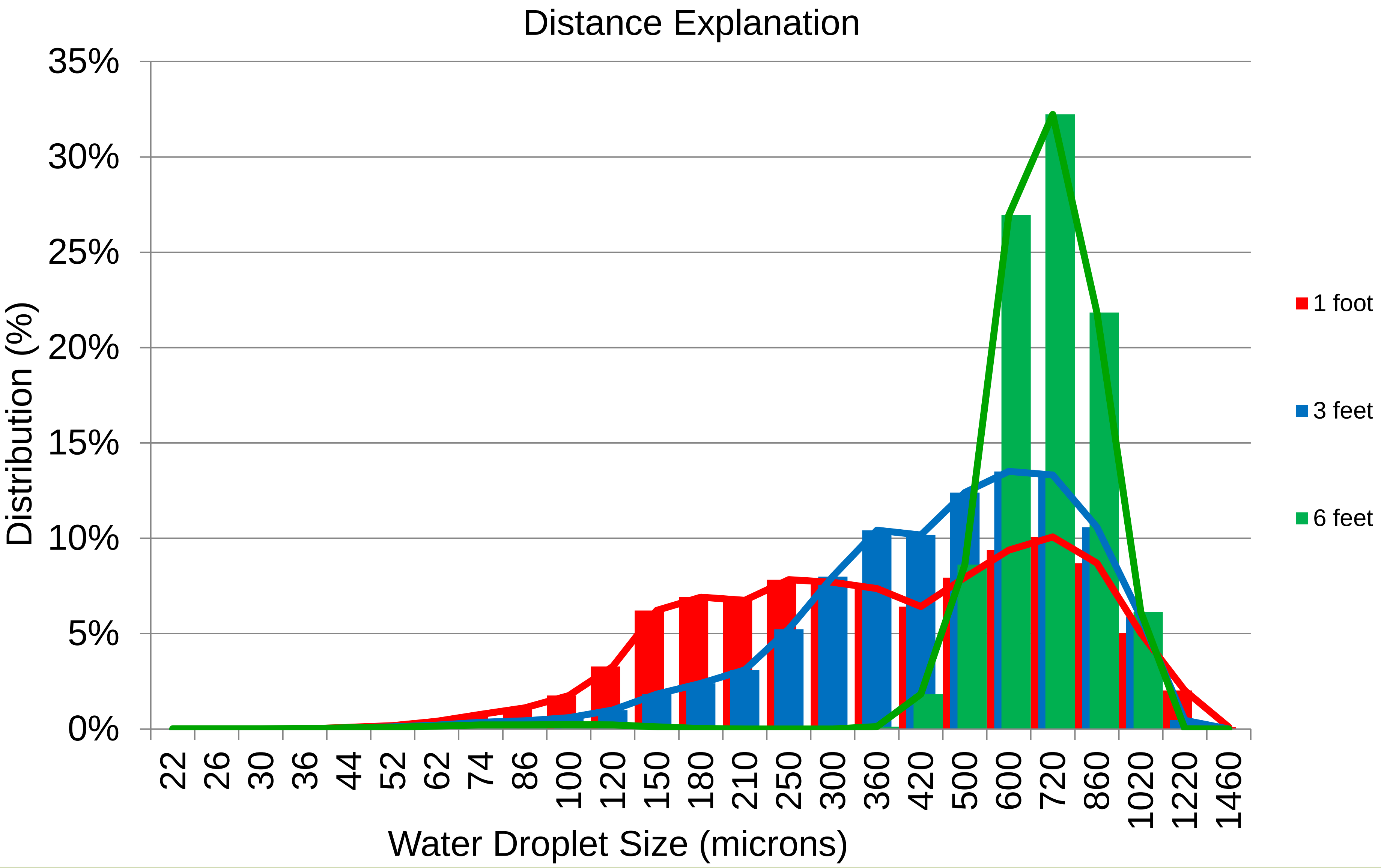


	Single DULQ View	DU vs. Wind Trend	AE(32) vs. Wind Trend
A	75%	1	2
B	72%	2	1
C	72%	3	3

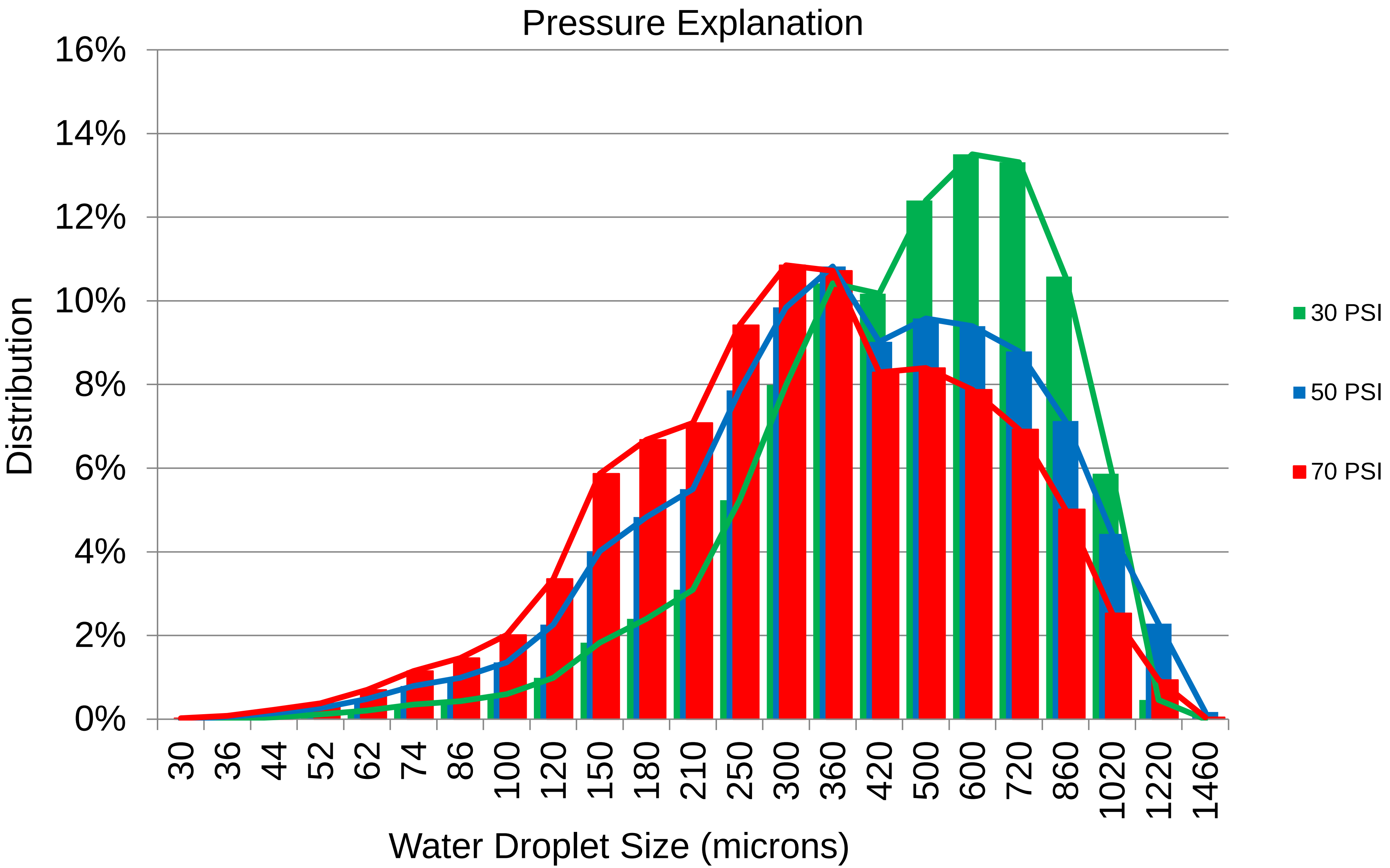
That’s Great…Now What?

- **So does this mean we should spend months and months evaluating every nozzle that comes on the market outside before we can determine if it qualifies as ‘high efficiency’?**
  - It’s just not really practical, is it?
- **What else could we do to “short cut” this time to evaluate and get to the same conclusions? So, I started thinking….**
- **What if we measure water droplet volumetric distributions and find a correlation between known wind curves that we gather over time ?**
  - Could we then just scan a nozzle’s spray (in one day) and anticipate/model which wind curve it most closely resembles?
  - It turns out there are very well defined standards by American Society for Testing and Materials (ASTM) for measuring particle sizes that other industries use quite extensively

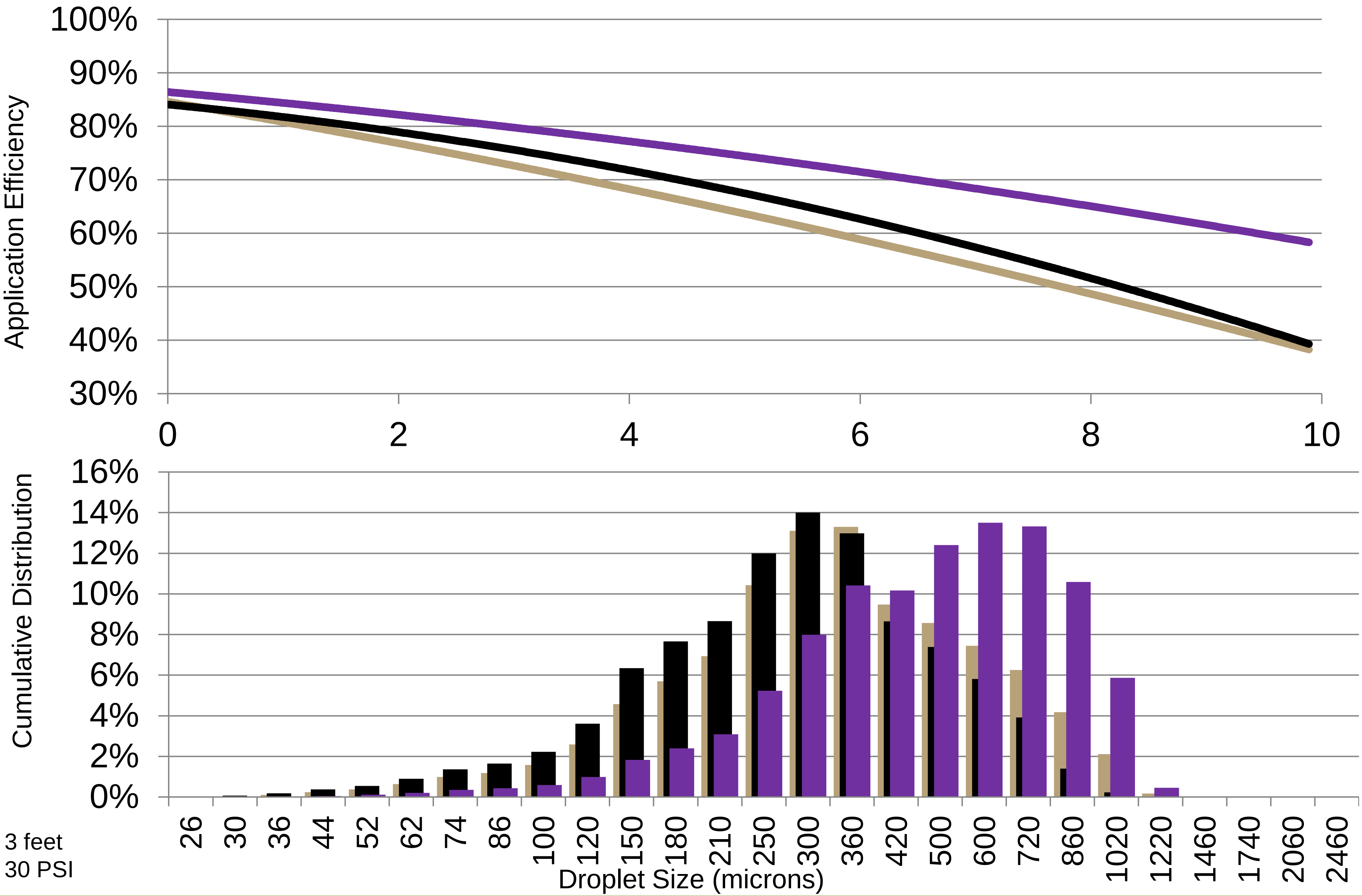
Water Droplet Size (Nozzle B)



Water Droplet Size (Nozzle B)



Is There a Correlation?



Drawing Conclusions

- **This provides enough evidence that with more data collection we will find strong correlations between droplet distribution measurements and wind curves**
  - It is possible this relationship has already been found in some “lost research paper of the past.” We should keep looking!

- **Although product’s efficiencies appear to be the same, there can be drastic differences in the “real world”**

- **By evaluating nozzles on a curve – versus single point – this would provide a more accurate picture of a nozzle’s efficiency factor**

Final Thoughts

- **Nozzle design accounts for a large amount of real-world performance differences**
  - Trade-offs exist to satisfy market demands (such as lower precipitation rates); however, those trade-offs may come at the expense of other factors – such as average water droplet size
- **If we continue to refine this approach:**
  - This can provide manufacturer's a method to design more efficient nozzles by creating nozzles that produce thicker droplets on average to fight wind – while maintaining high distribution uniformity
  - This can also provide agencies a more scientifically based method of determining efficiency of the nozzle when it is used outside (in a reasonable time frame)
- **Implications on other efficiencies, such as pressure regulation**
- **What's next?**
  - Continue to validate correlations through testing
  - Remember no single variable answers!
  - Find ways to measure efficiencies by the "And's"

QUESTIONS?

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Support Slides

The Real World

- **All manufacturers published results are based upon indoor testing – where there is no wind and the climate is well controlled**
  - But that's not where the product is actually used, right?

- **Let's be fair; historically, this has been the best way to test due to numerous factors – testing outside would:**
  - Be Expensive
  - Take too long to fully test and release a product to market
  - Have too many variables
  - Have too much variation in test method from manufacturer to manufacturer
  - Arguably pose challenges to maintain repeatability

The Setup

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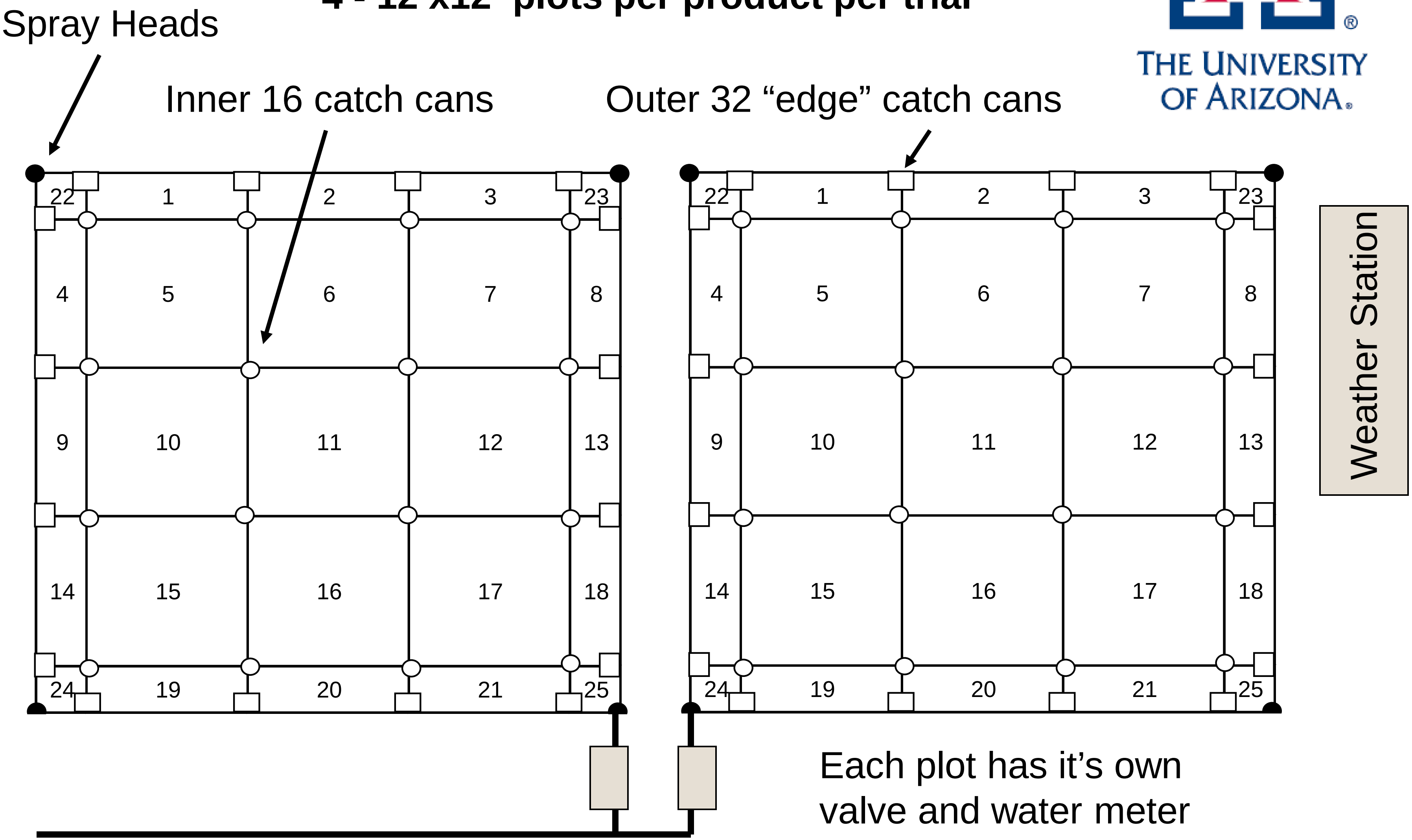
- **Three head-to-head trials were executed during each season**
- **Each nozzle model is given qty 4 – 12x12 plots next to each other.**
- **Each plot has its own water meter and is calibrated to provide ½ inch of water per irrigation cycle.**
- **Each nozzle was installed on a PRS stem to ensure optimal performance.**
- **Each plot starts irrigation at the same time each day, at least 3 times per week.**
  - Irrigation cycles set in the morning, per widely held belief this is the best time to do so – for multiple rationales.
- **During each irrigation event, a weather station records temperature, wind direction, humidity, and wind speed every 15 seconds.**
- **Standard catch-cans are installed at grade level and measurements are recorded immediately after every irrigation event.**
- **Data was analyzed after every run to track and determine if more runs are necessary to ensure statistical relevance.**

The Setup

4 - 12’x12’ plots per product per trial



Each plot has it’s own valve and water meter