West Valley Probabilistic Performance Assessment:

Introduction to Distribution Development

QPM August 2020

Introduction

- Goal here is to set the stage regarding the basics of distribution development

- Subsequent QPMs will go into more detail about the specifics of distributions developed for the PPA model

Decision Context

- Site decommissioning under NRC's License Termination Rule (LTR)

- LTR encourages probabilistic performance assessment (PPA) as a way to account for uncertainty

Dealing with Uncertainty in PPA

- Input probability distributions are necessary for each parameter in the model to represent uncertainty

- Some key parameters include…
  - Inventory
  - Kd
  - Erosion rates

Dealing with Uncertainty in PPA

- What is a probability distribution?
- How do we develop probability distributions?
- Let’s consider an example

Cookies

- Let’s consider the situation where there is a public meeting and cookies will be provided

- How do we know how many cookies are needed?

Cookies

- We would like to know…
  - How many people are coming to the meeting?
  - How many cookies will each person eat?

Cookies

- Scenario 1
- Guess that each person eats 2 cookies and 10 people will show up
- We have 20 cookies, what if 35 people show up?
- Not having enough cookies is never a good thing

Cookies

- Scenario 2
- Guess that each person eats 2 cookies and 100 people will show up
- We have 200 cookies, what if 35 people show up?
- We have too many cookies

Cookies

- Simply guessing the number of people and number of cookies per person is likely to result in far too many or far too few cookies

- If we used information from previous meetings about the number of people attending and the number of cookies eaten per person, we would make better decisions

Cookies per Person

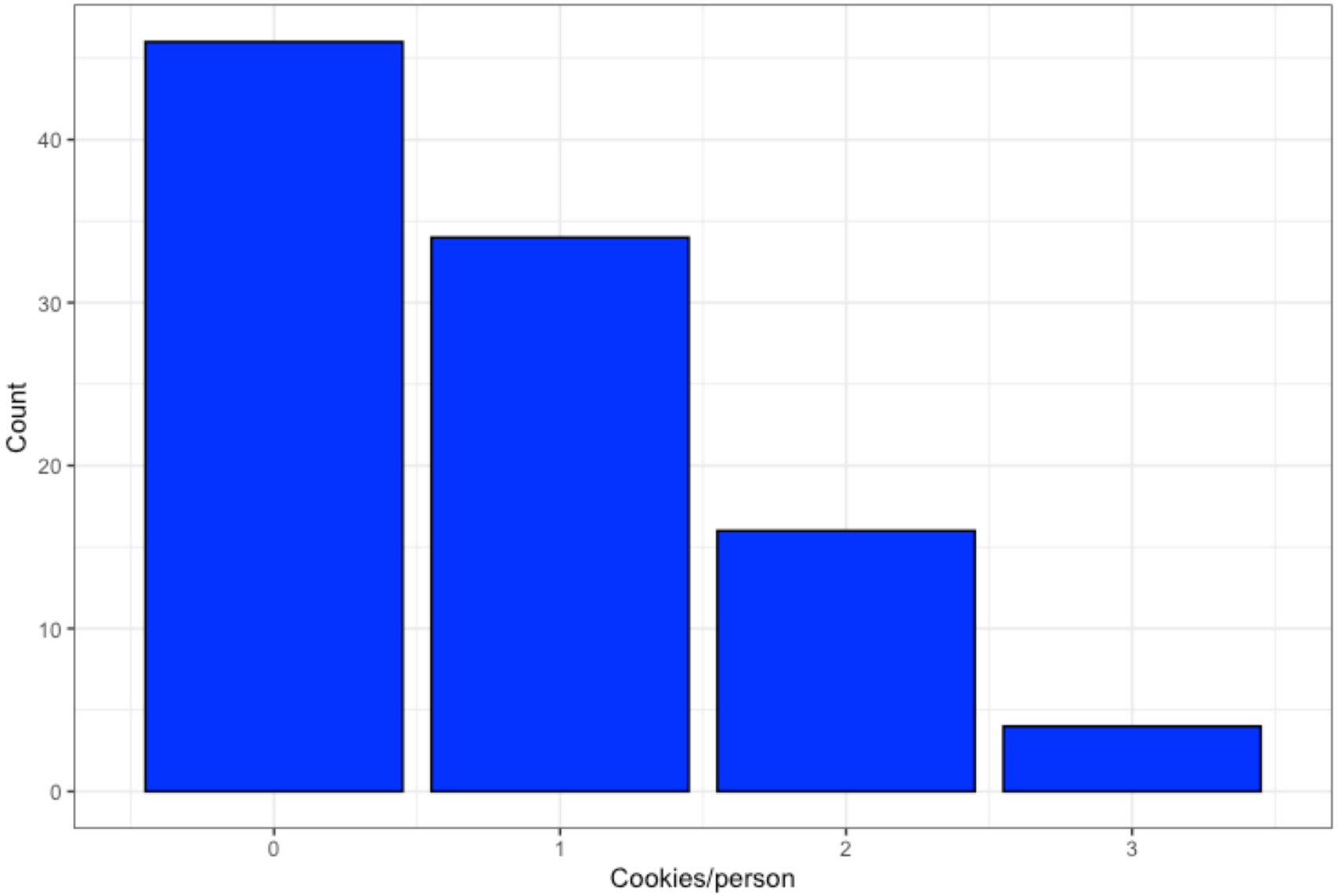
- At a previous meeting…
- Bill ate 2 cookies, Tracey ate 1 cookie, etc
- More complicated in reality
  - Same people may eat different numbers of cookies at different meetings
  - Are data per person or per meeting, per year?

Cookies per Person

- Let say the number of cookies eaten per person has been measured for 100 people during previous meetings

Number of Cookies per Person	Number of People That Ate That Many Cookies
0	46
1	34
2	16
3	4

Distribution of Cookies per Person



Cookies per Person

- The distribution of the “cookies per person” data represents how individuals behave

- We don’t want to make decisions based on how many cookies a single person eats (0, 1, 2, etc)

Cookies per Person

- For example, would it be reasonable to use the value of 0 cookies/person to help inform how many cookies we need at the next meeting?
- How about 3 cookies/person?
- What might be more reasonable?
- What would you pick?

Cookies per Person

- To address this type of question, we are interested in aggregating information across many people

- One common way to aggregate information across many people is to use the average

Cookies per Person

- We will consider using the average number of cookies eaten per person

- The estimate of the average # of cookies eaten per person is 0.78

Average Cookies per Person

- If we collected data from another 100 people (across multiple meetings), we will get different data…with a different average…is one better?

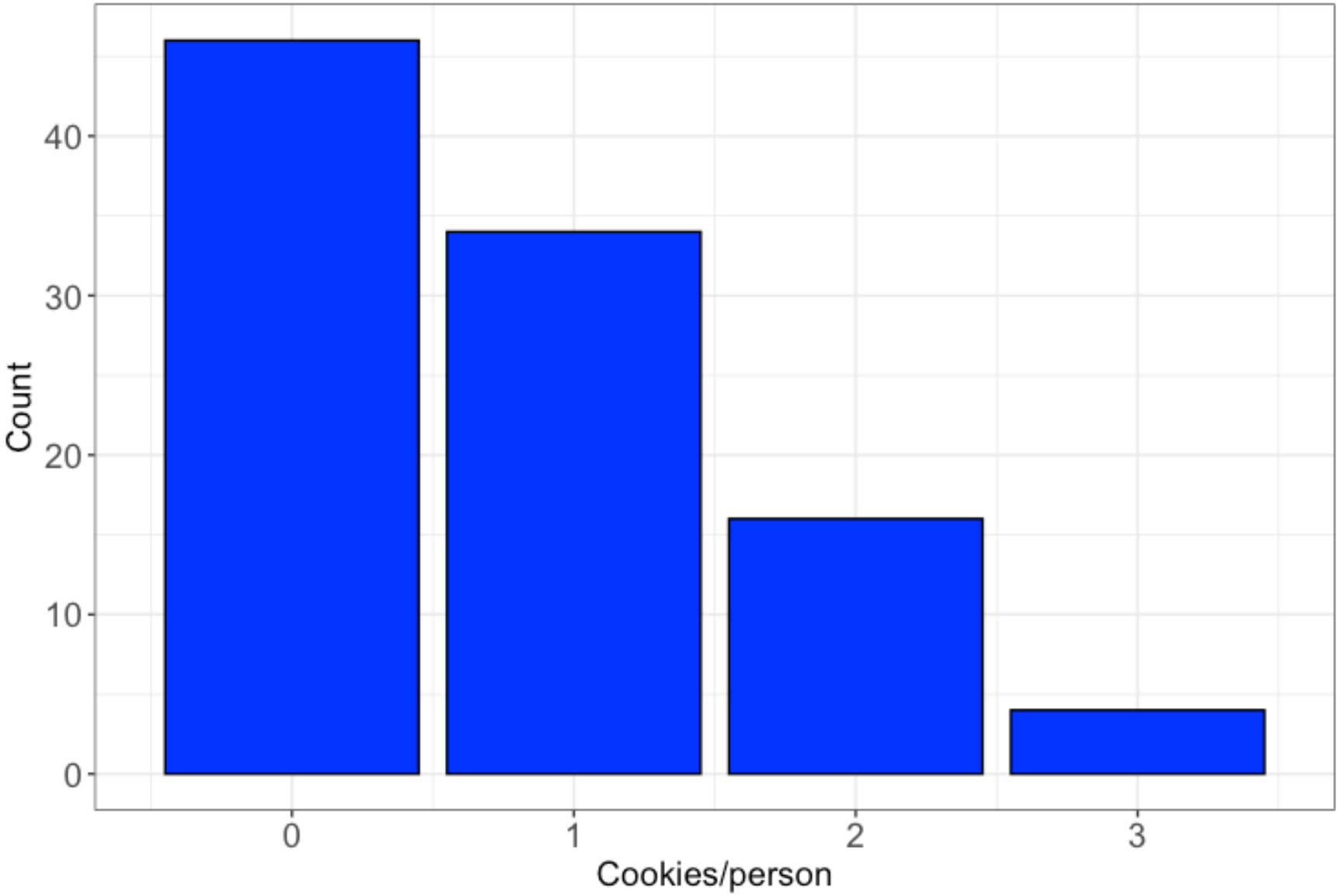
- We can use math to get a better sense for how the average will vary among different meetings

Cookies per Person

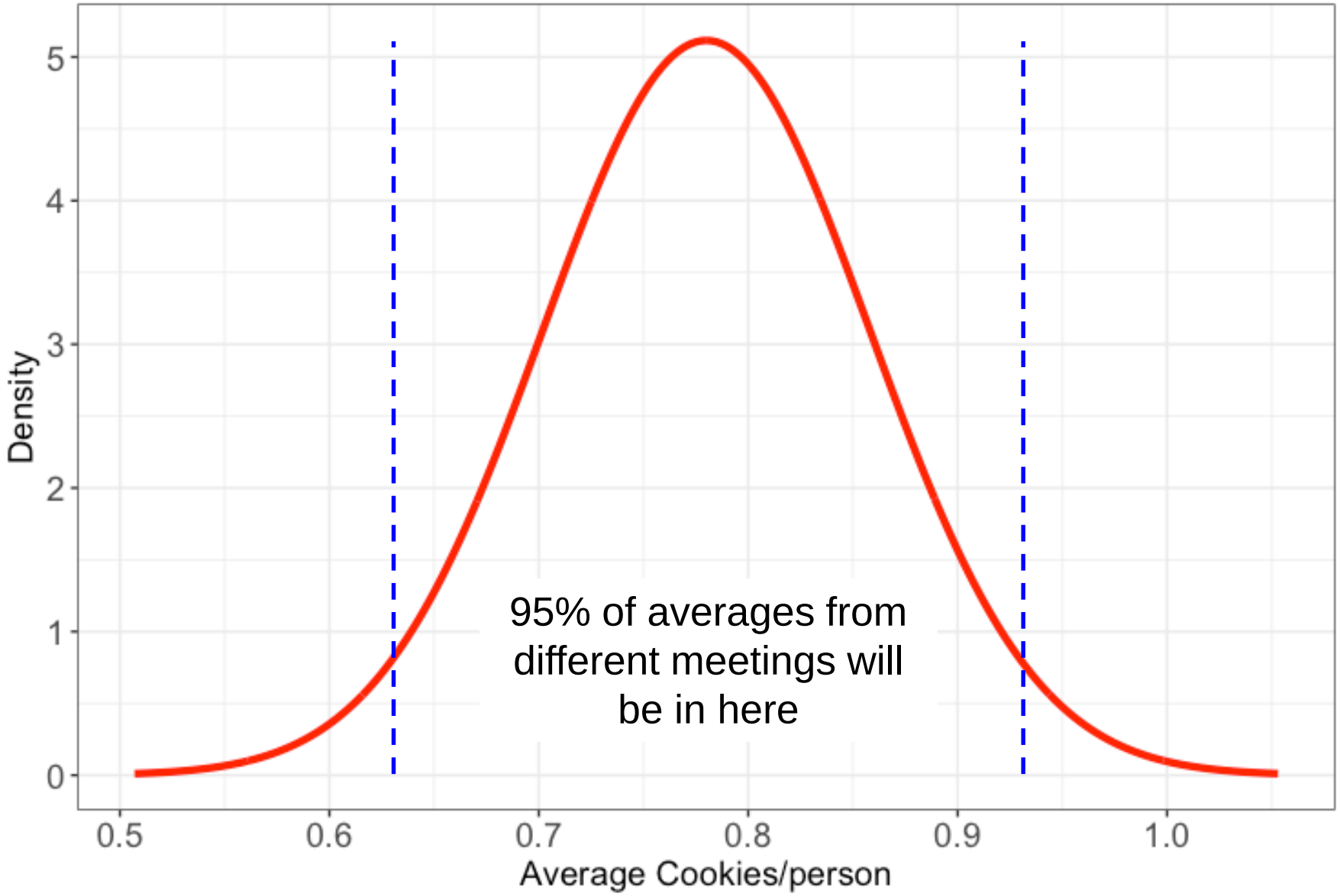
- We can characterize the behavior of the average number of cookies estimated from different meetings

- Specifically, using the information collected from past meetings, we can estimate the probability distribution of the average # of cookies eaten

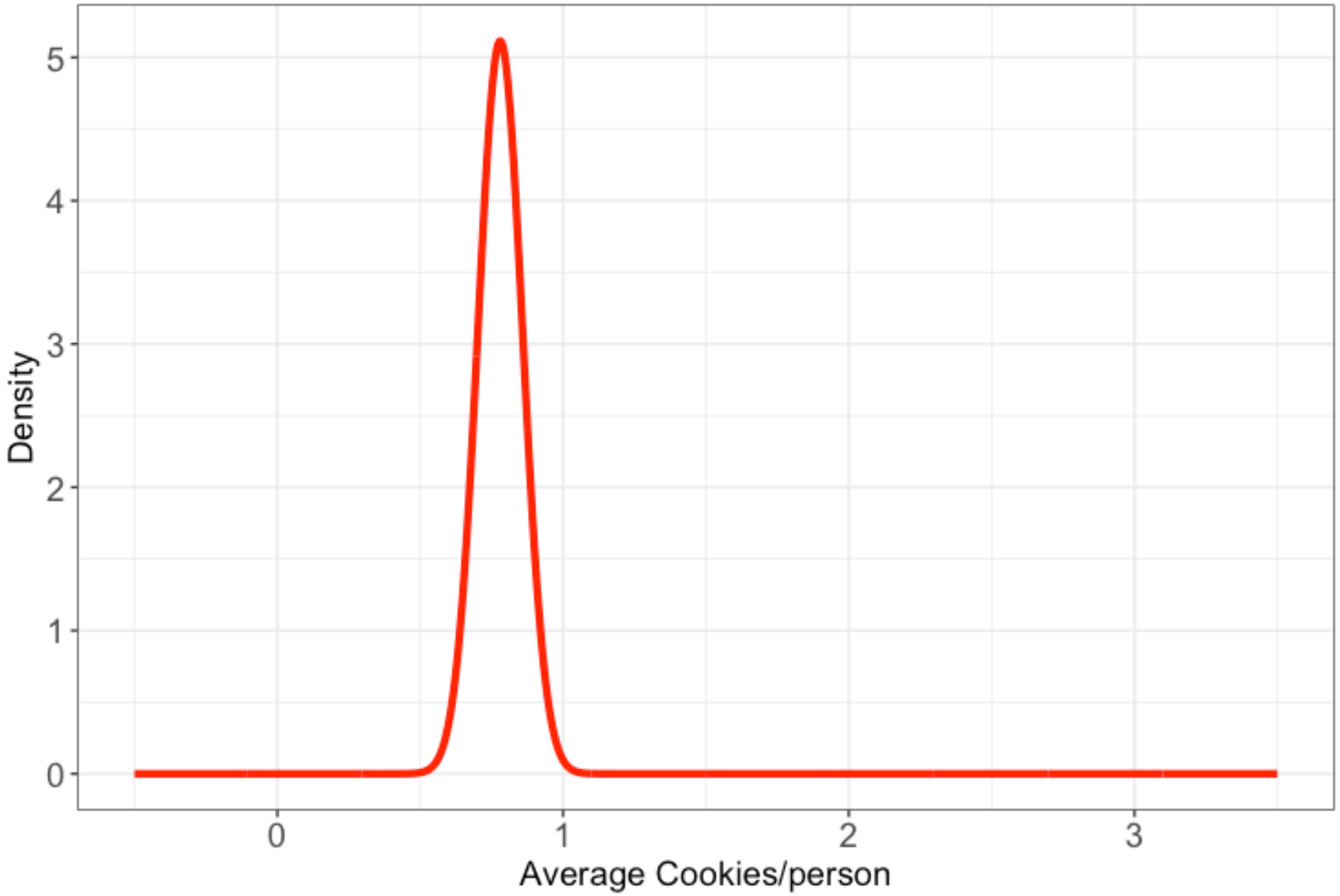
Distribution of Cookies per Person



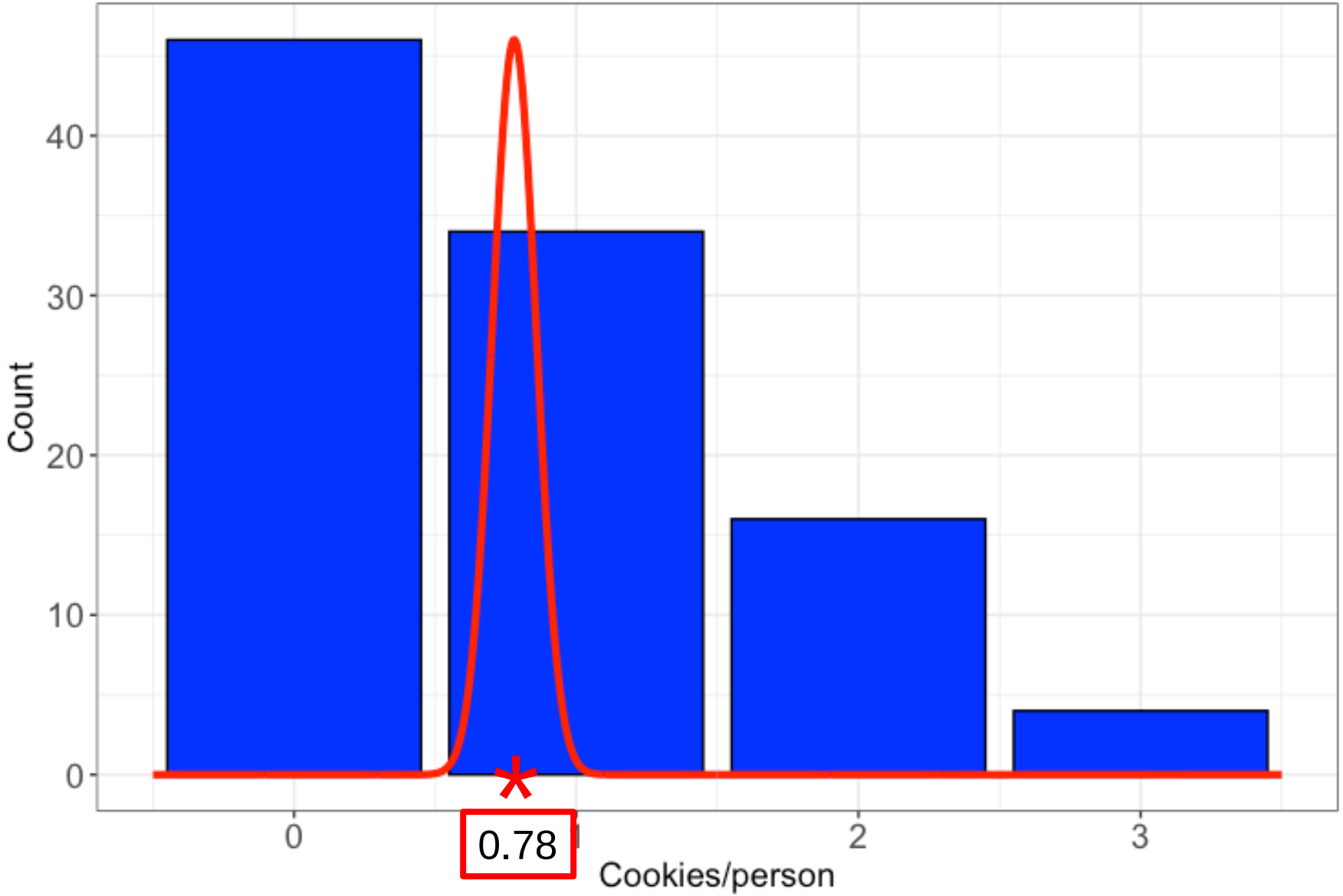
Distribution of Average



Distribution of Average



Distribution of Data & Distribution of Average



Extreme Cookie Eating

- What if we encounter a person that can eat an extreme number of cookies?

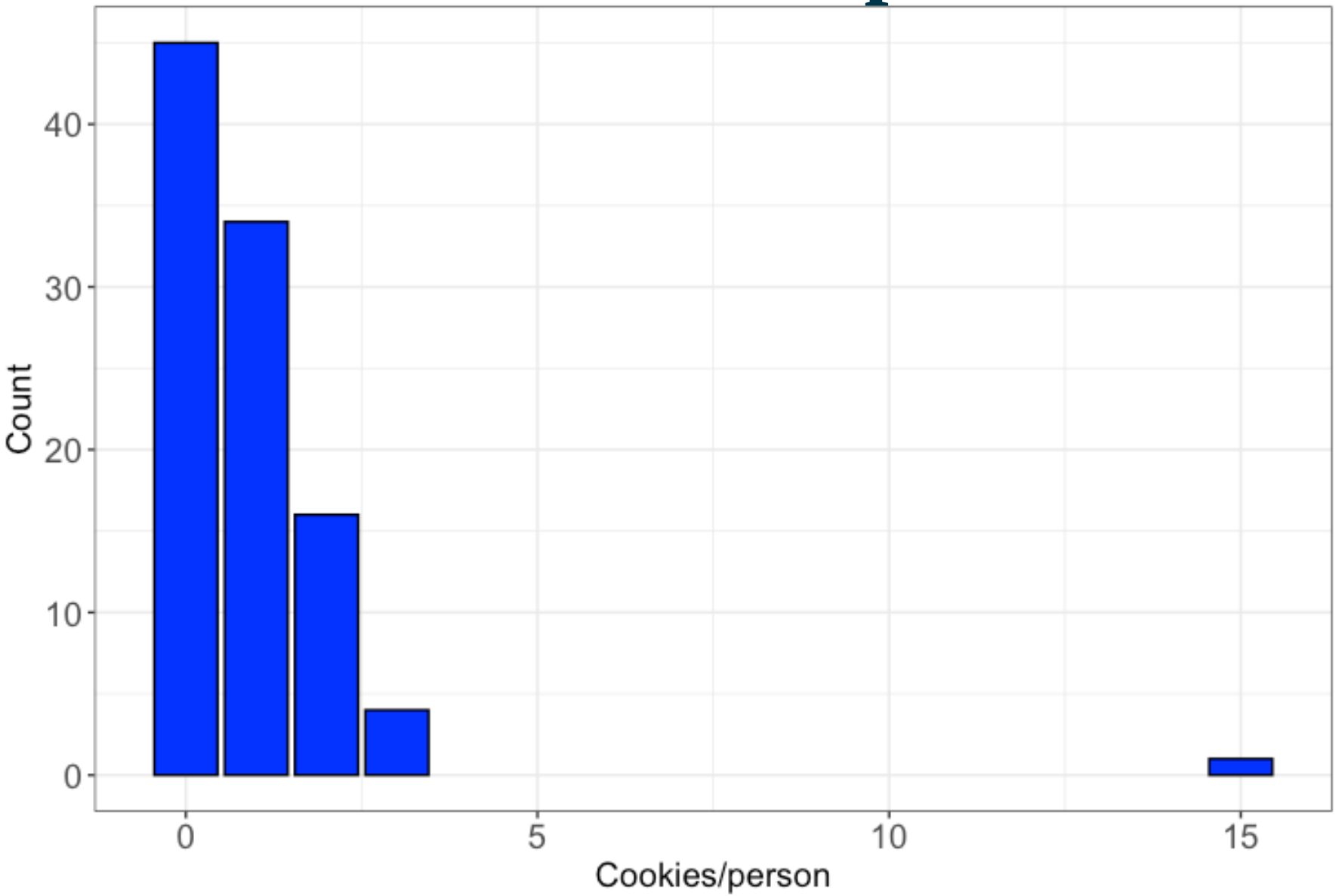
- Let’s say we have one person in our sample of 100 that ate 15 cookies

Cookies per Person

- Let say the number of cookies eaten per person has been measured for 100 people during previous meetings

Number of Cookies per person	Number of People that ate that many cookies
0	45
1	34
2	16
3	4
15	1

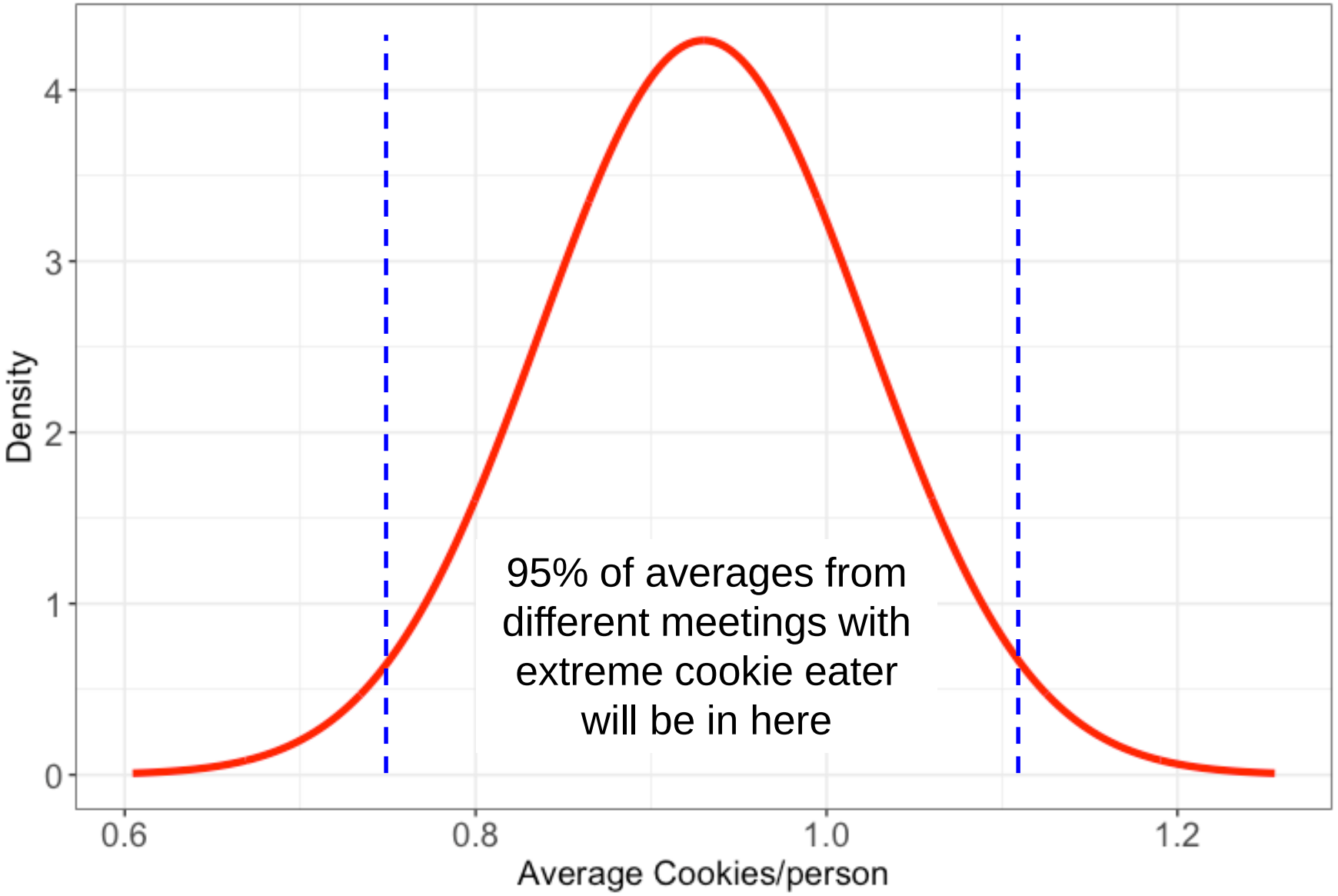
Distribution of Cookies per Person



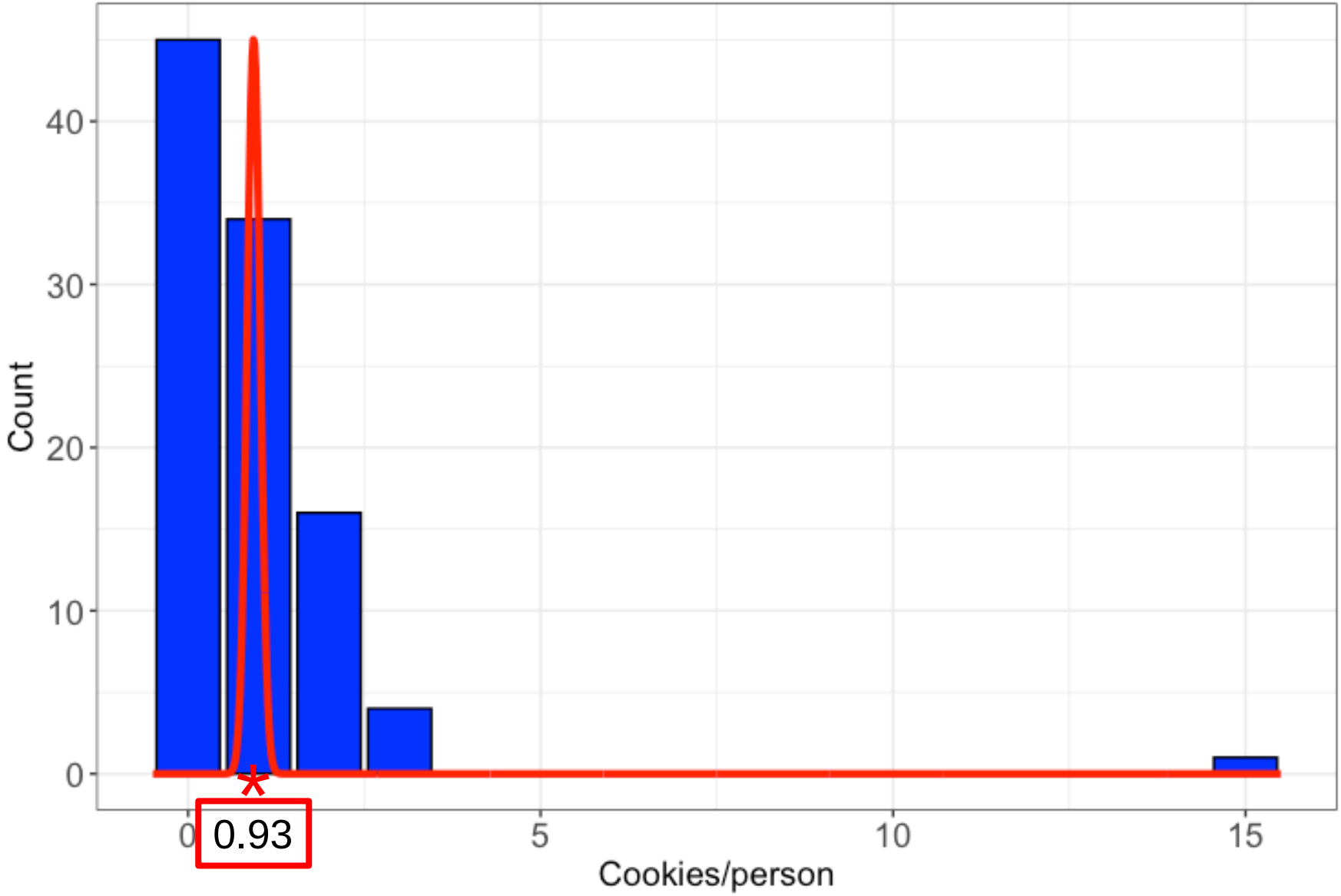
Average Cookies per Person

- What happens to the distribution of the average when we have an extreme cookie eater?
- Turns out the average is responsive to extreme events

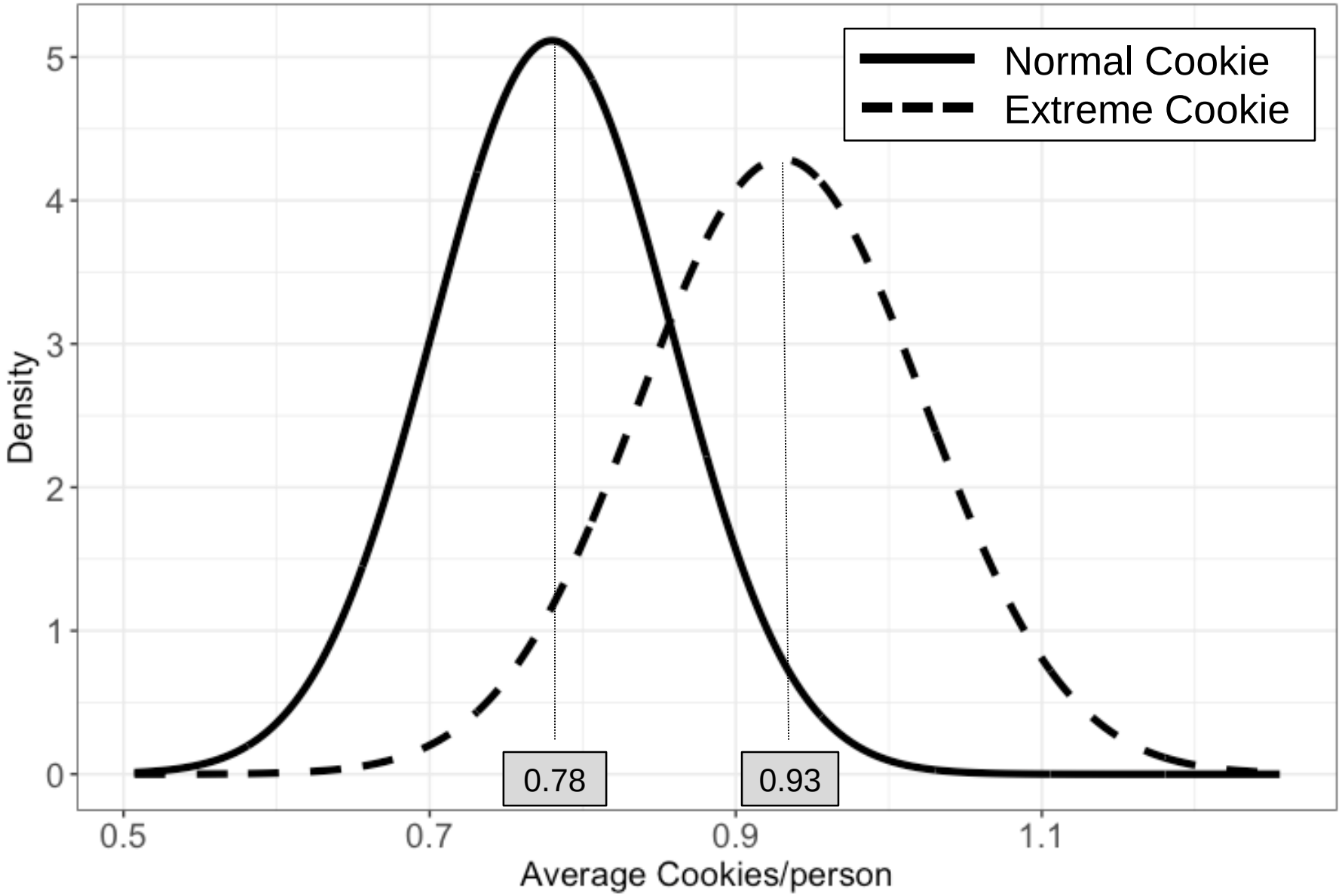
Distribution of Average



Distribution of Data & Distribution of Average



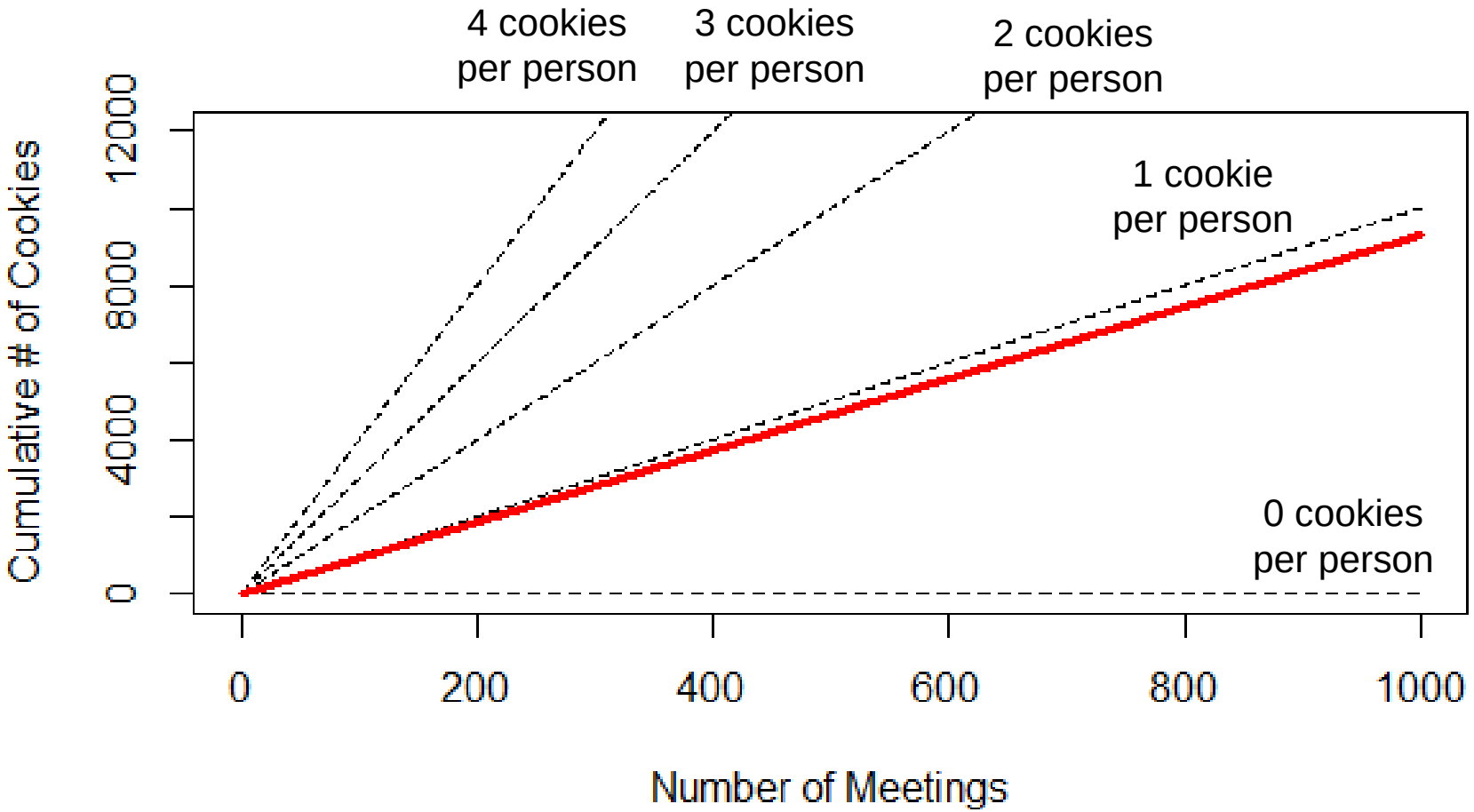
Distributions of Average



PPA Distributions

- For the PPA model, we use behavior about averages for parameters
- The PPA model selects a single value for each parameter at the beginning of a run and uses that same value for hundreds of years
- Sampling from data distributions can result in unrealistic inputs for modeling

- Cookie purchases are best informed by the average (red)



Types of Information

- Different sources of information can be used to inform distributions
  - Observational Data (Cookies, Erosion, Hyd. Cond.)
  - Modeling results (Erosion, inventory)
  - Experimental Studies (Kd)
  - Literature review and interpretation (Kd)
  - Expert elicitation
- Combinations of sources are used where possible
- Despite the variety of possible sources, data are sometimes sparse

Types of Information

- Different types of data can have varying levels of information

- There is a difference between knowing how many cookies a single person at a meeting eats, versus knowing the average number of cookies eaten at a meeting

Types of Information

- Suppose at a given meeting, Fred ate 2 cookies
- We also know that the average number of cookies eaten per person at that meeting was 4
- Are these two pieces of information comparable?

NDA Inventory

- Distributions are developed based on information from previous studies
  - NFS burial records – “data”, but of variable quality (i.e. inconsistent data)
  - URS 2000 calculations – essentially a model of potential maximum site inventory
- There are two pieces of related information here
- Not the same as two “data points”

NDA Inventory

- Target is distributions per radionuclide per decision unit
- Decision units (e.g. disposal holes or segments of trenches) are subject to Phase 2 decisions
- PPA helps inform that decision making

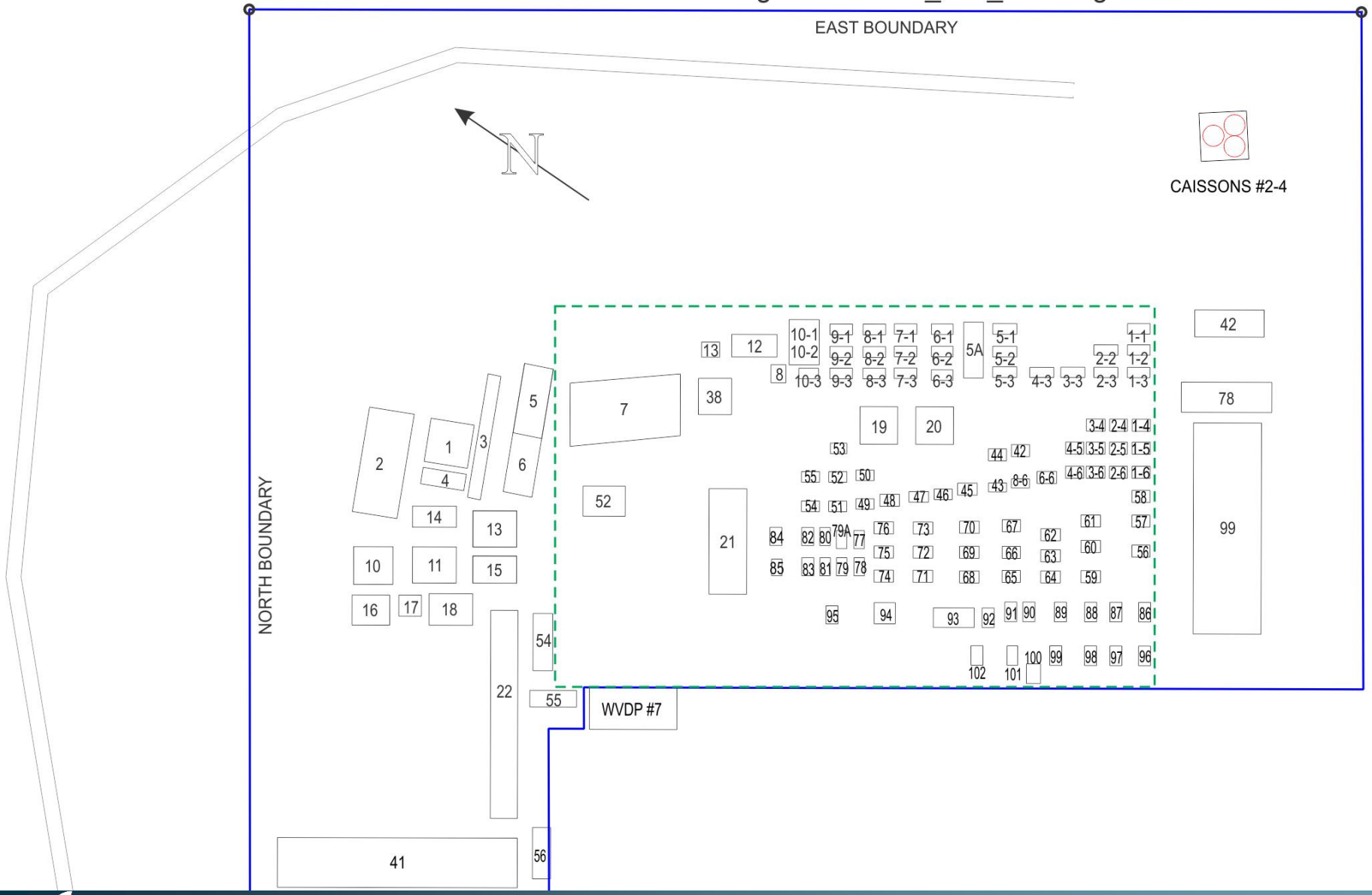
NDA Inventory

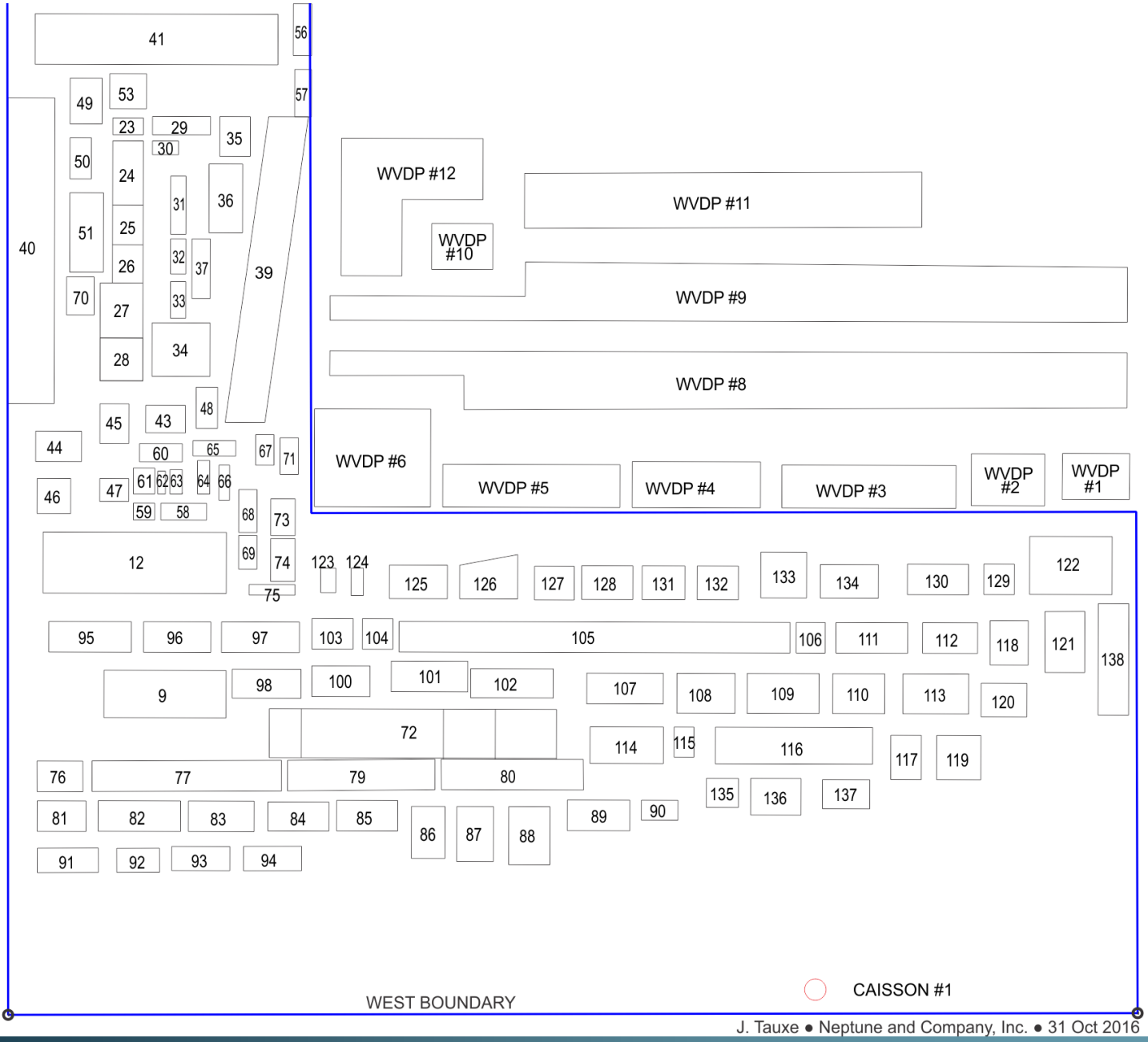
- In practice, uncertainty was incorporated at the individual database record level

- Information and uncertainty were combined across multiple records into a single distribution

NRC-LICENSED DISPOSAL AREA

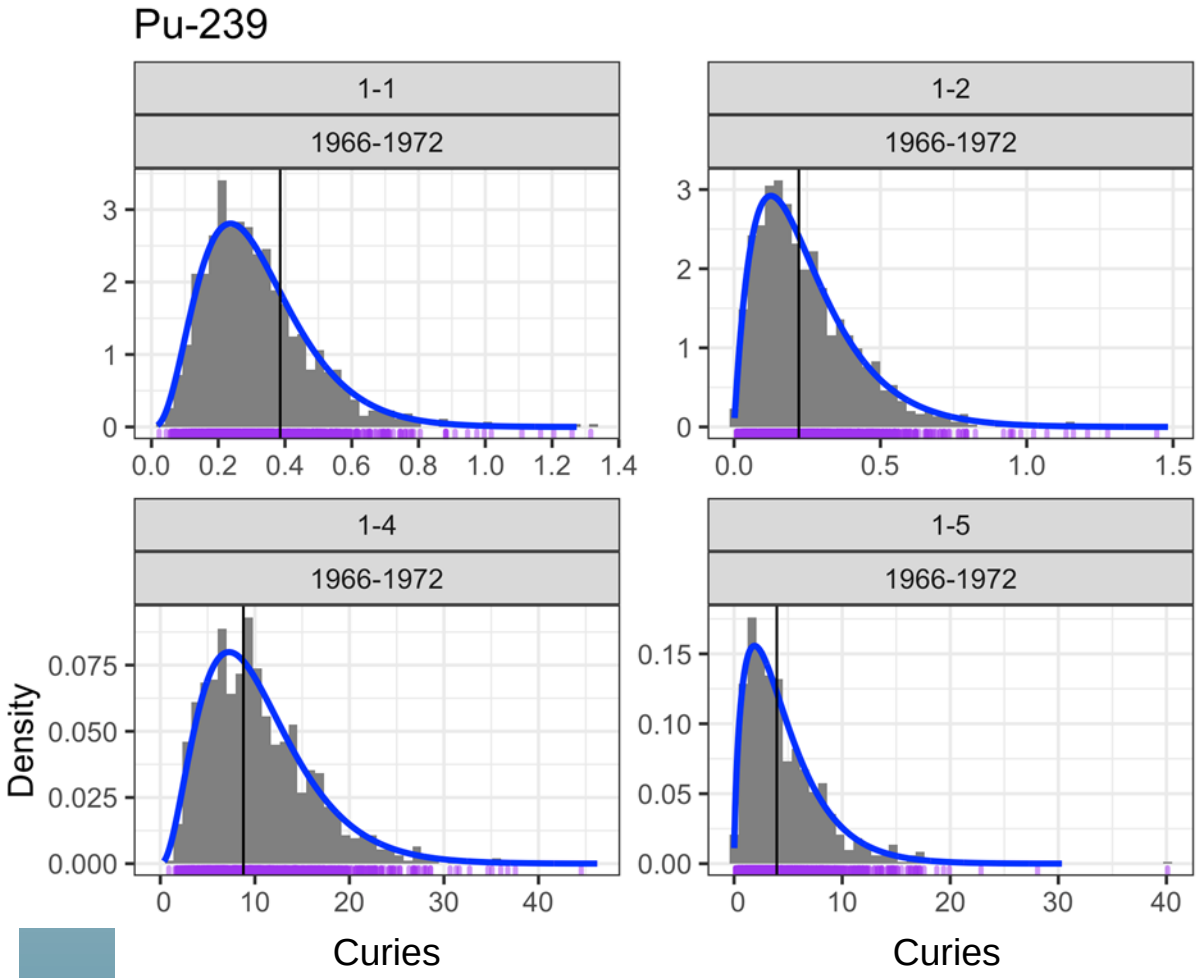
Derived from drawing 900-E-4974_001_002.dwg





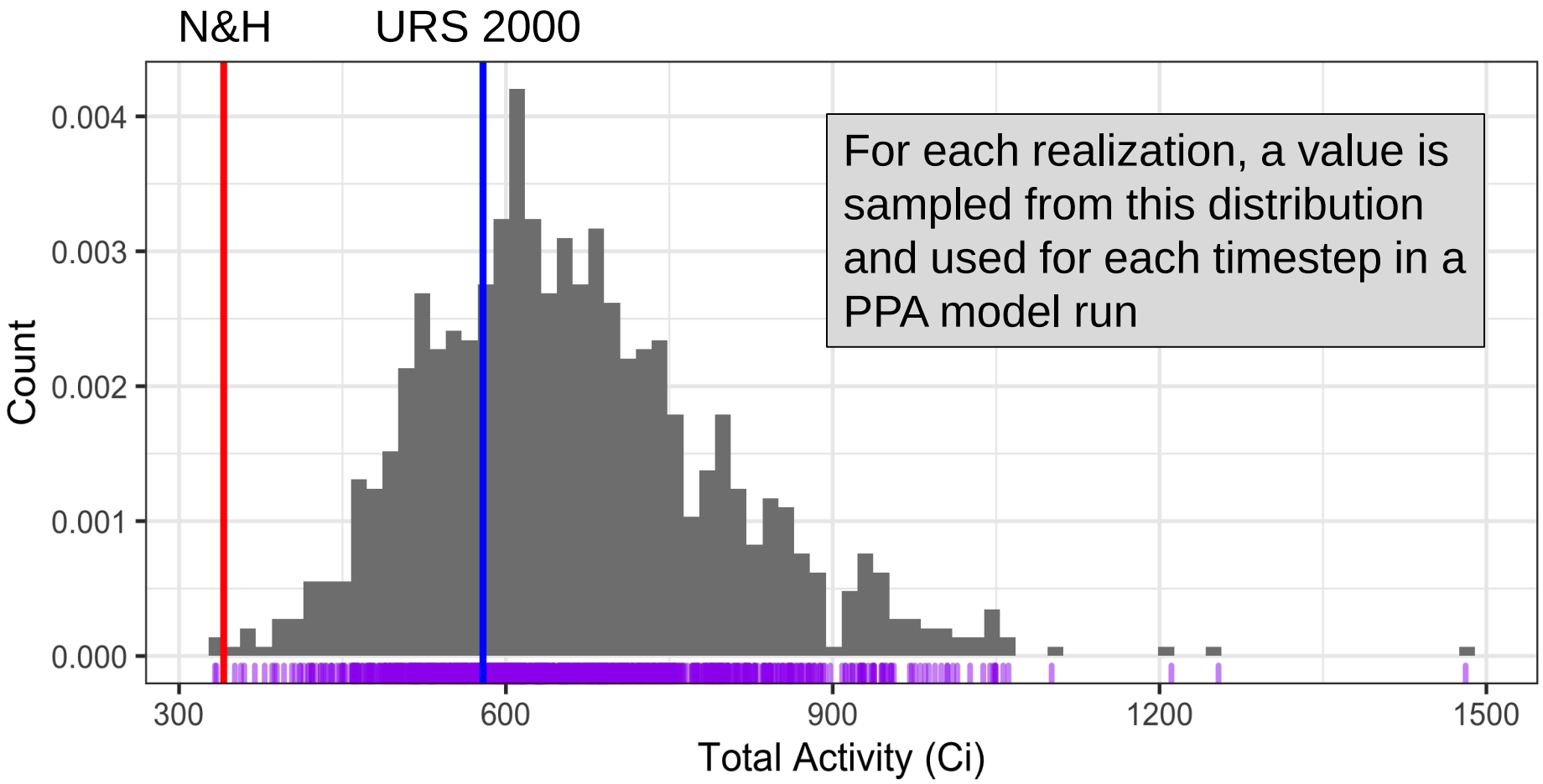
J. Tauxe ● Neptune and Company, Inc. ● 31 Oct 2016

^{239}Pu by Deep Hole and Time



- Gamma distributions
- Vertical line indicates the estimate reported in URS (2000)

^{239}Pu for all NDA Decision Units and Times of Disposal



Summary

- Best available information is used to accurately estimate values while incorporating uncertainty

- Future QPMs will provide more details on the specifics of distribution development for inventory, erosion, Kds