Water Productivity:
Are we really sure about this?

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Water Productivity

Many studies, authors, and papers

Many variations on the theme

Many calls for maximizing some form

Few, if any, questions raised . . . .

What is Water Productivity?

It is a ratio...

$$\frac{\text{Some measure of output}}{\text{Some measure of the water input}}$$

There is nothing inherently conceptual . . .

Some Examples of WP Ratios

$$\text{WP (AW)} = \frac{\text{Yield (tons)}}{\text{Applied Water (ML)}}$$

$$\text{WP (ET)} = \frac{\text{Yield (tons)}}{\text{Evapotranspiration (ML)}}$$

$$\text{WP (IRR,R)} = \frac{\text{Revenue (Dollars)}}{\text{Irrigation + Rainfall (ML)}}$$

Preliminary Observations

1. The information is limited

Yield = Yield (Water | Nutrients, Planting Date, Seed Quality, Sunshine, Degree Days, Labor, Weed Control, Pest Control, etc.)

Revenue = Revenue (Yield | Price, Quality, Fruit or Grain Size, Sugar Content, etc.)

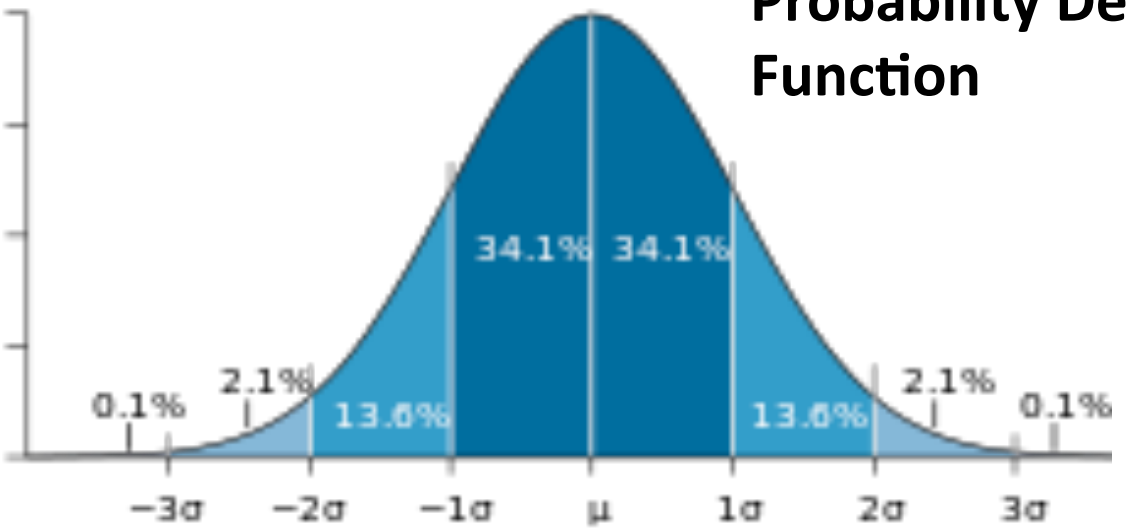
2. Yield and Revenue are Random Variables

Yield = Yield (Water | Nutrients, Planting Date, Seed Quality, Sunshine, Degree Days, Labor, Weed Control, Pest Control, etc., ε_y)

Revenue = Revenue (Yield | Price, Quality, Fruit or Grain Size, Sugar Content, etc., ε_R)

Both the Numerator and Denominator in WP calculations come from distributions

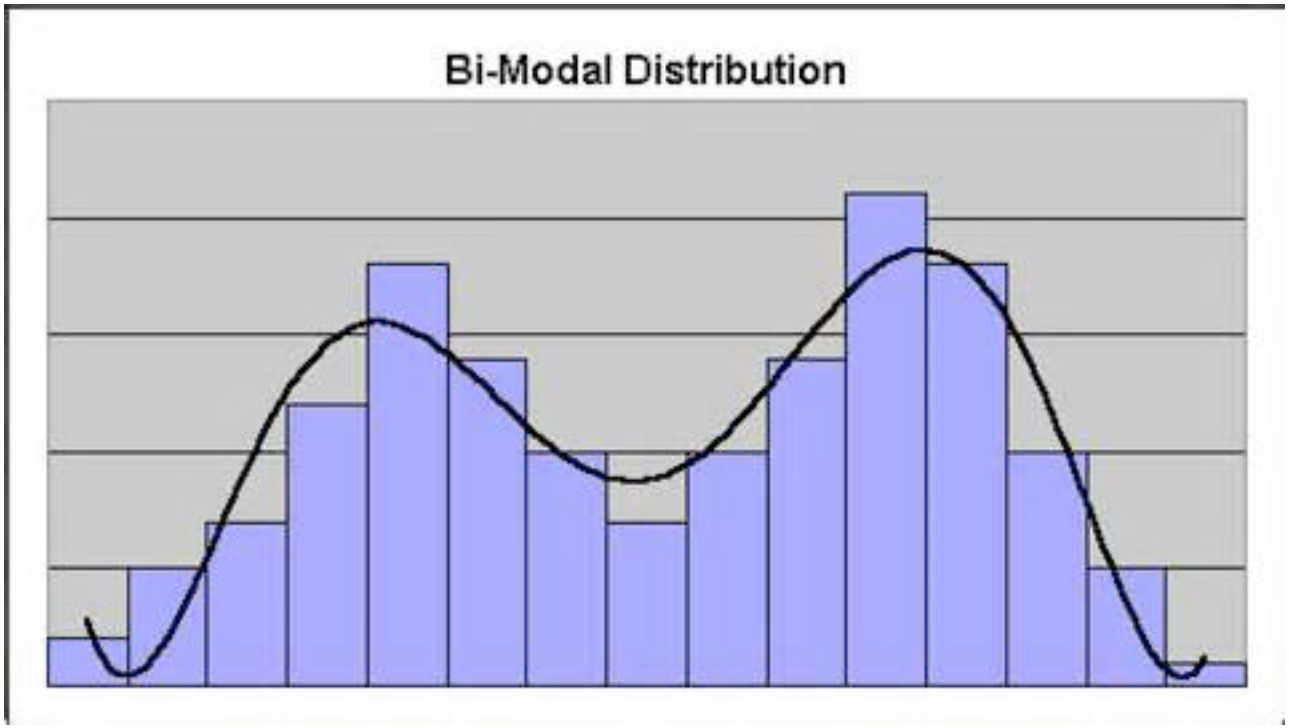
Frequency



Crop Yield (tons / ha)

Rainfall often is characterized by a bi-modal distribution

Frequency



Rainfall (mm / year)

Irrigation also embeds uncertainty . . .

Farmers can control the volume of water at the turnout, but they cannot control . . .

the field distribution uniformity,
ambient conditions while irrigating,
plant health status, interactions with plant nutrients, soil conditions, etc.

Irrigation carries a large error term, (ε_{IRR})

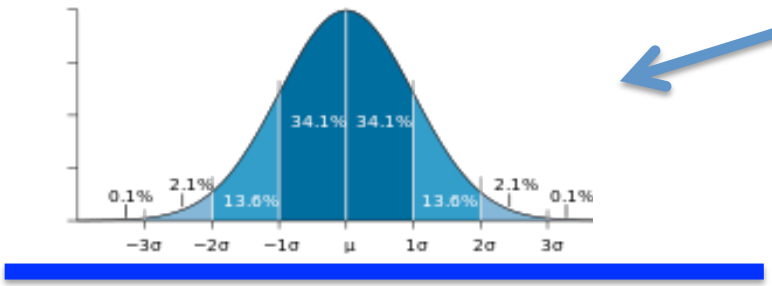
Transpiration and ET also are random variables

Thus, any calculation of Water Productivity should be treated as a random variable . . .

Yet we rarely see reports of means and standard deviations, or tests of statistical significance when comparing WP calculations.

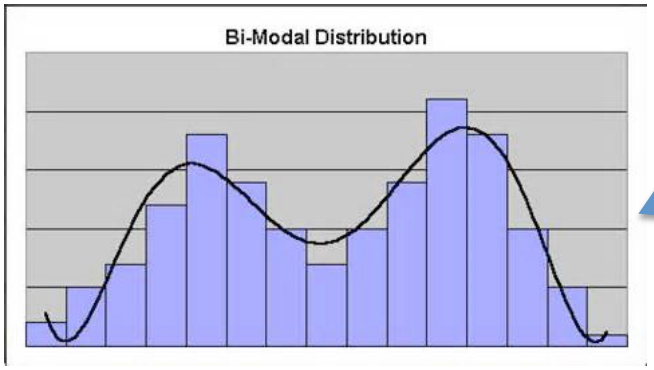
Many forces act upon the probability distributions

Consider WP (Rainfed)



Farmers certainly strive to move the distribution of crop yields, over time

Nature also modifies and shifts the distribution



Nature and farmers modify the distribution of effective rainfall, as well

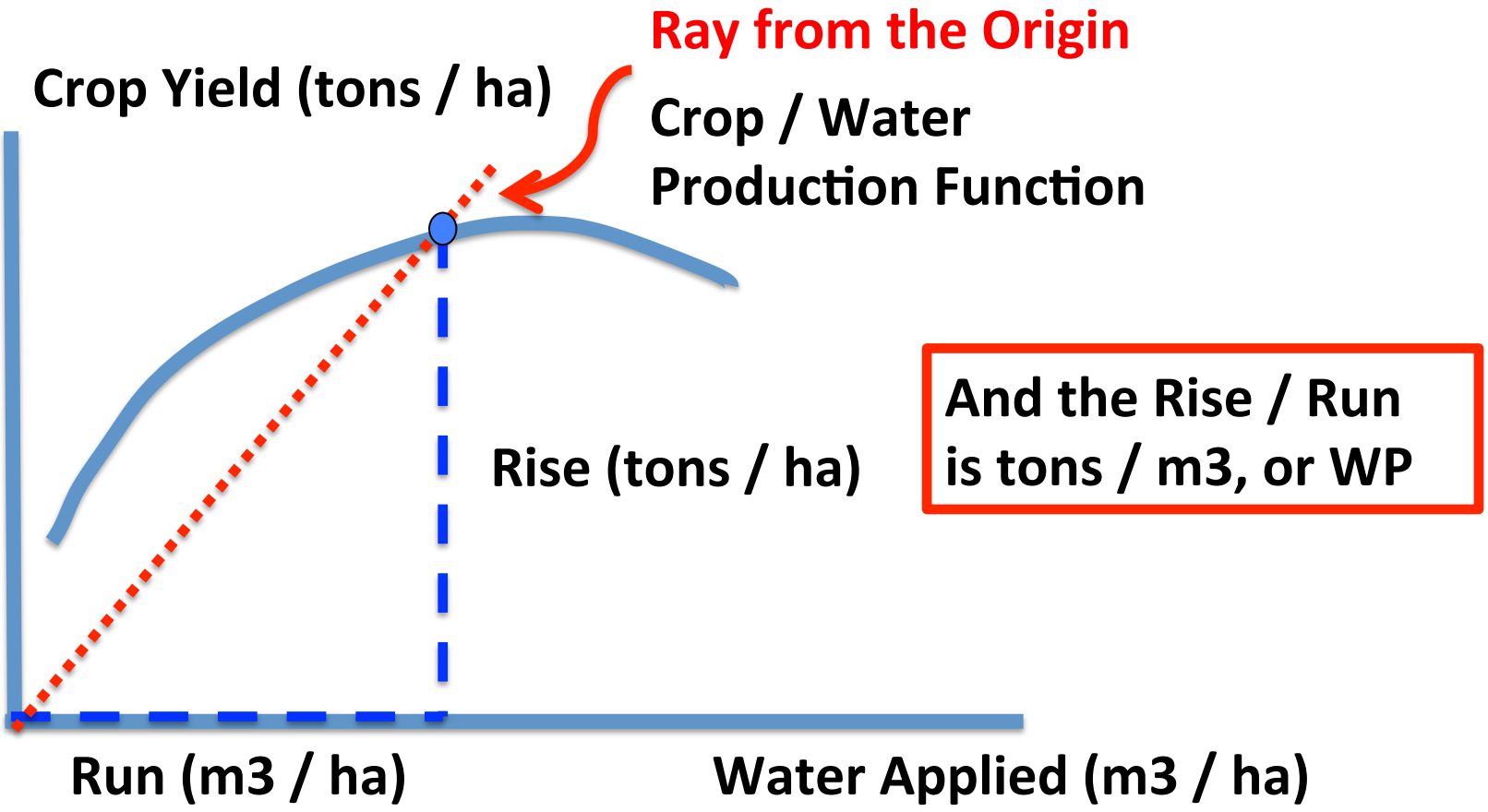
3. Does anyone strive to maximize Water Productivity?

There is no fundamental framework or theory that generates such an optimizing criterion

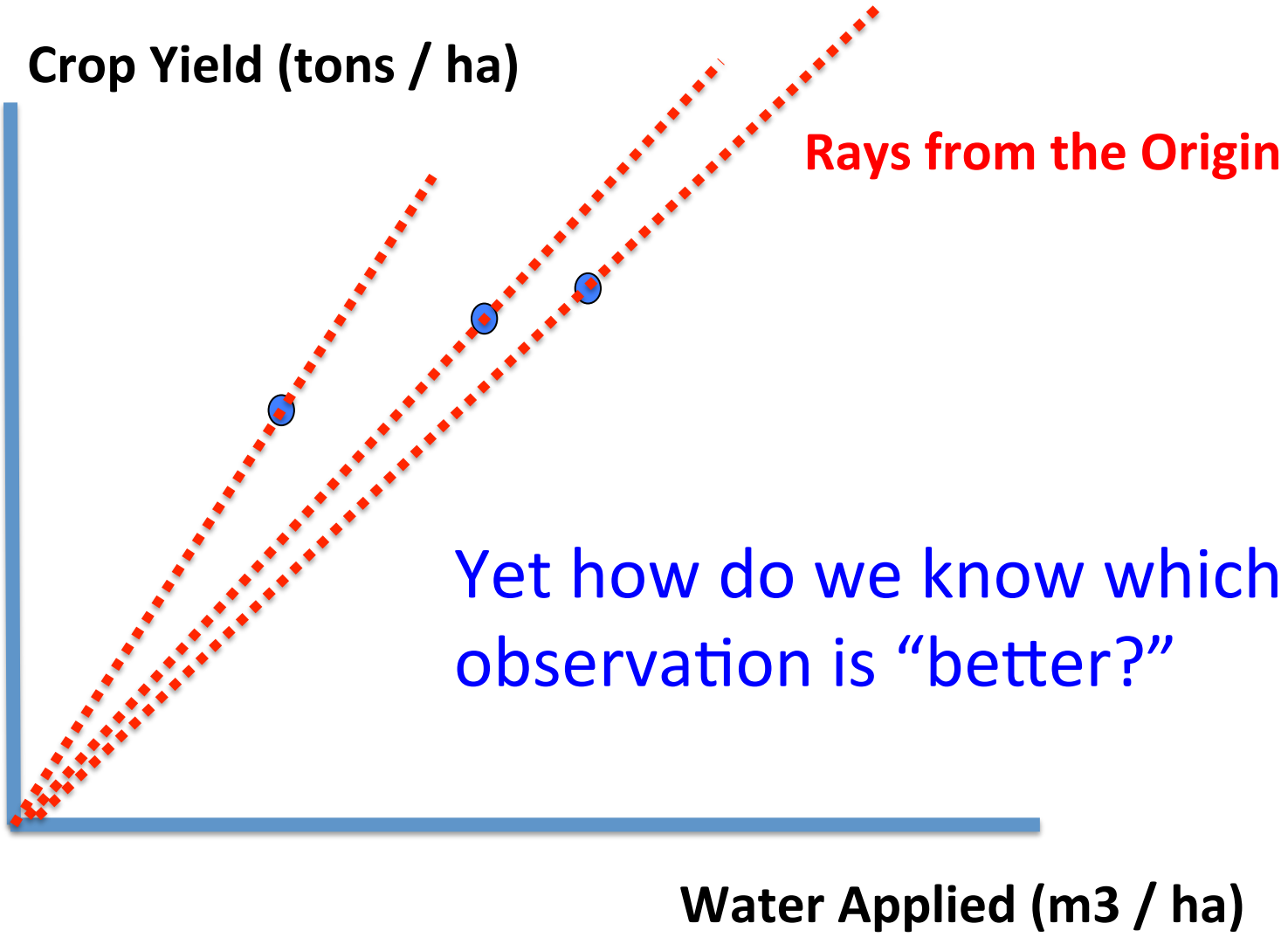
Most farmers optimize over some form of a utility or profit function

Farmers in rainfed conditions absolutely must manage risk. Farmers with irrigation also must manage risk and uncertainty.

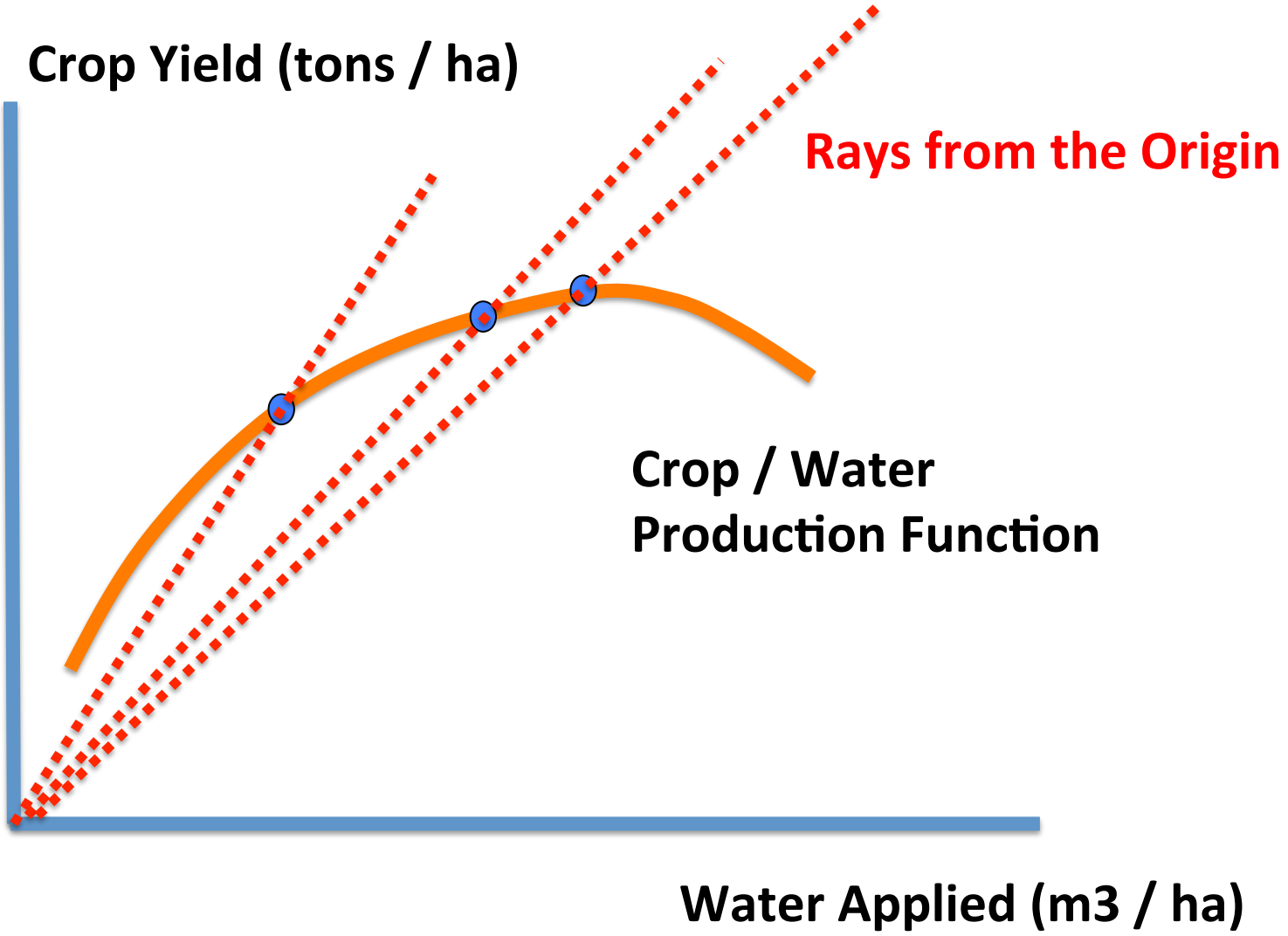
4. Are comparisons of Water Productivity helpful?



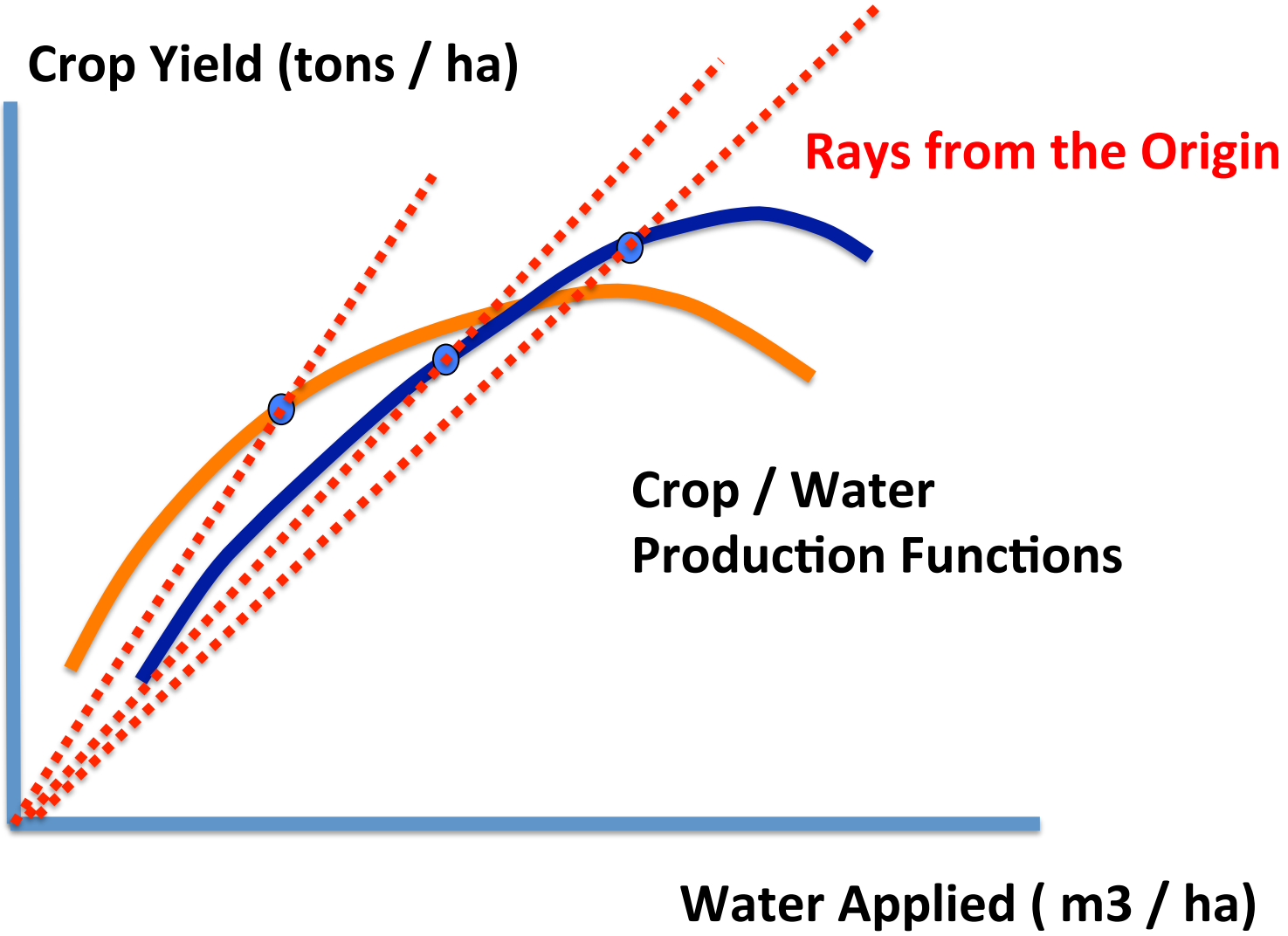
We can quickly evaluate WP estimates using rays from the origin



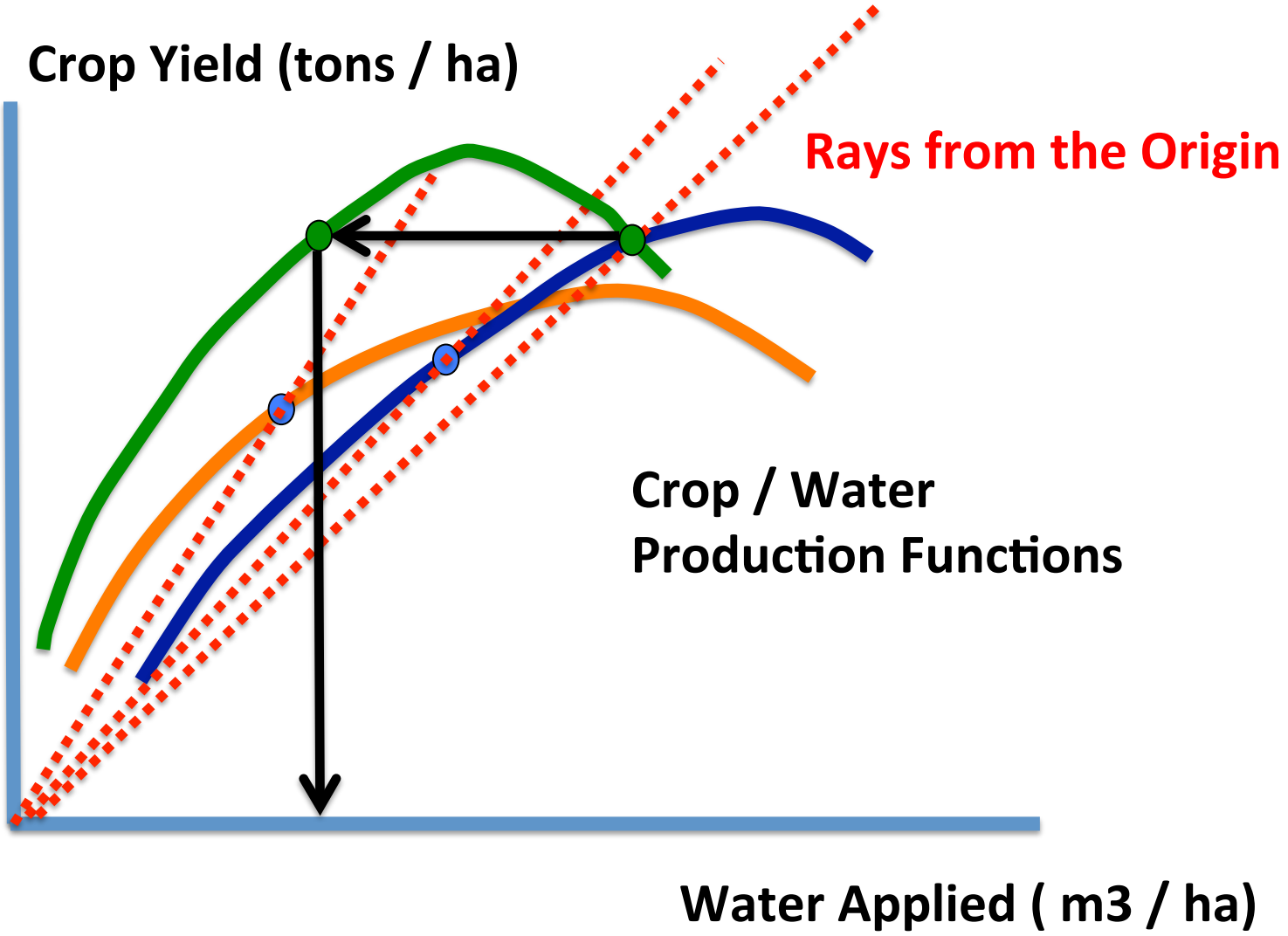
At a minimum, we need to examine the economics



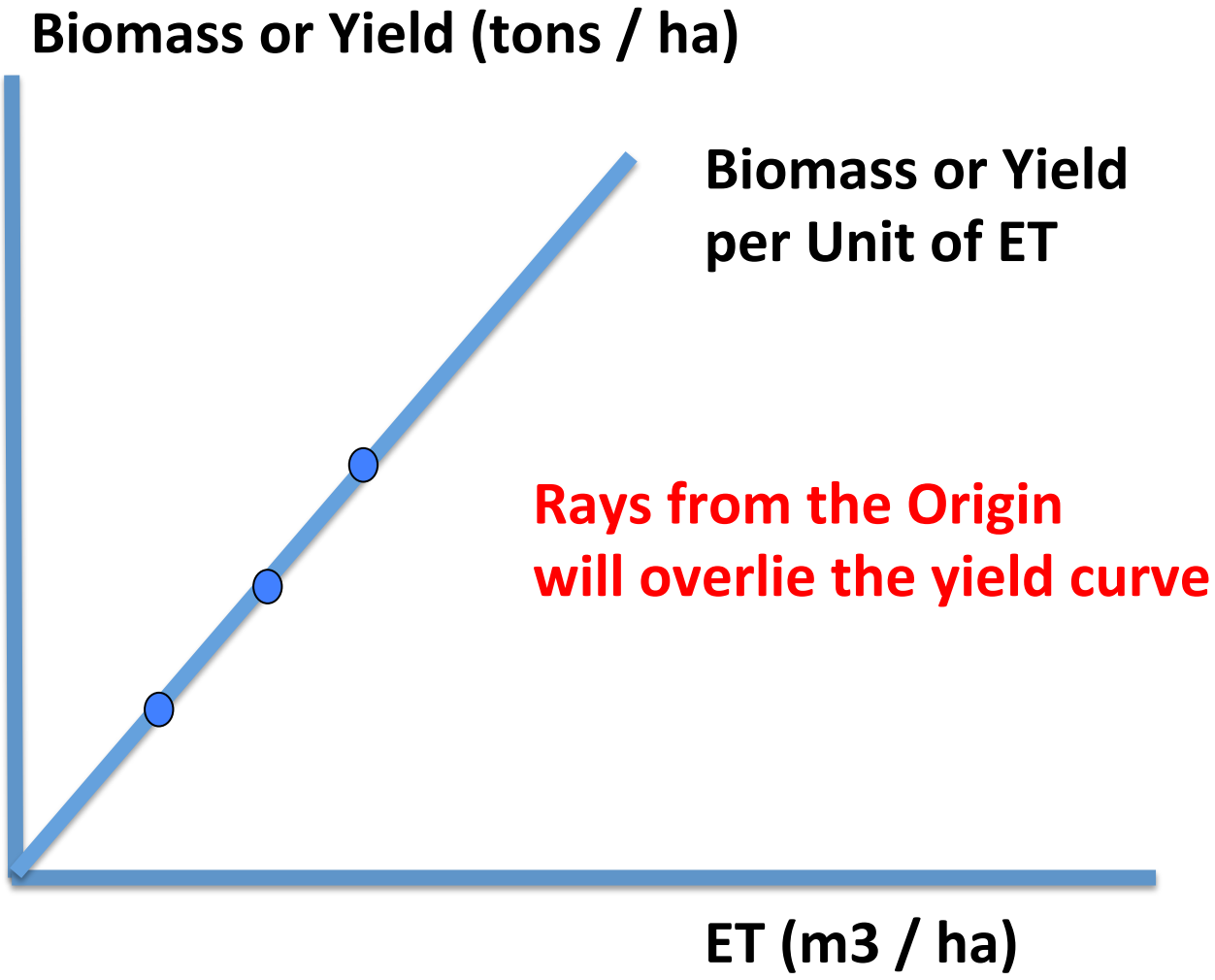
We also need to know about the underlying production functions



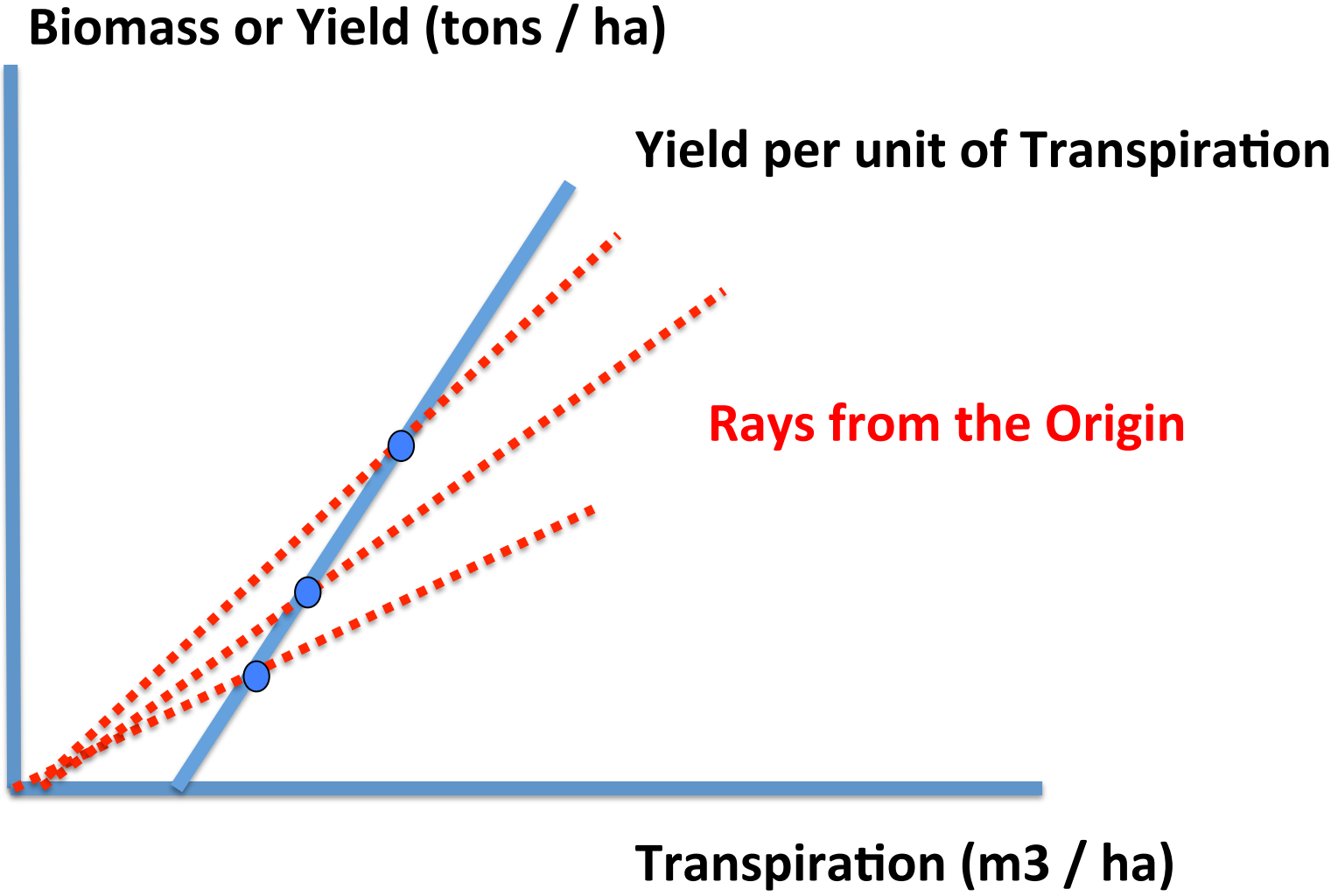
Any number of situations is possible . . .



WP (ET or T) also is problematic . . .
Consider WP (ET)



Consider WP (T)



5. There is an implied notion that higher measures of WP are better than lower measures

Yet, there is no supporting, underlying theory

Nor is there any compelling empirical evidence

In policy settings, such a prescription could be potentially harmful

Summing Up

Water Productivity is a calculation. It is not a conceptual framework or a fundamental principle of agronomy or hydrology.

Water Productivity focuses on just one input

Both the numerator and denominator are random variables

Summing Up . . .

Comparisons across time or geography are not necessarily meaningful.

Farmers likely do not maximize Water Productivity; nor should they.

Researchers generally do not measure the many factors determining their estimates of Water Productivity.

Policy prescriptions based on WP analysis can be potentially harmful.

Water Productivity:

Are we really sure about this?

Thank you very much for the opportunity to share this perspective