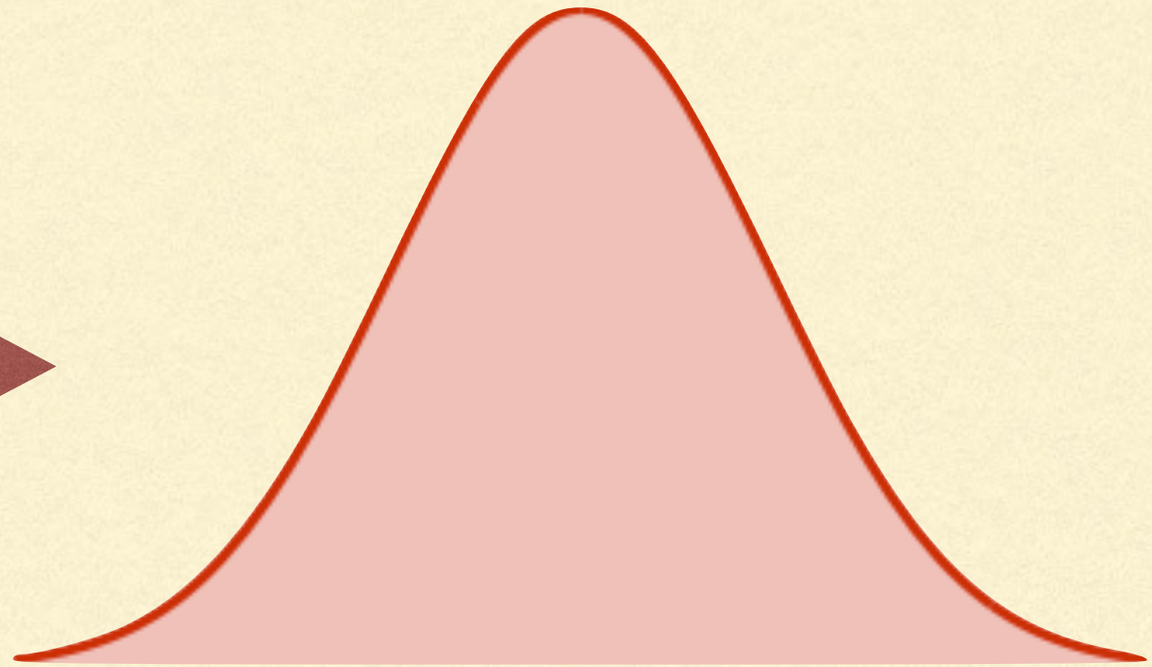
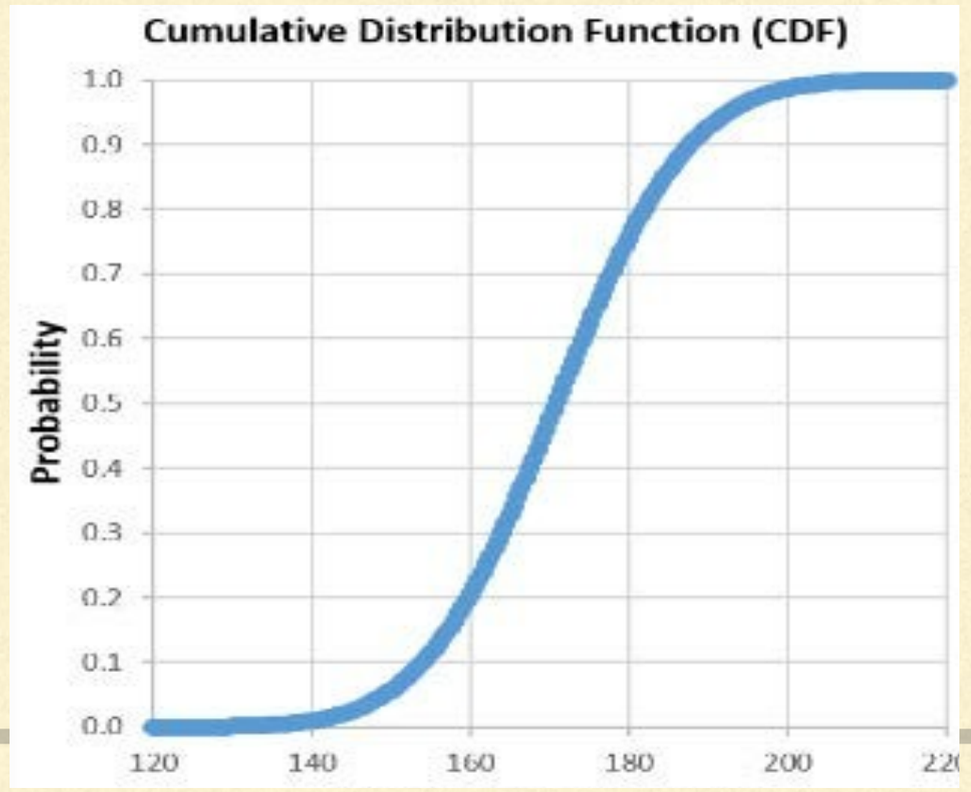
EXPERT ELICITATION
+
STRUCTURED DECISION MAKING

Expert Judgement

- Can play a key role in science and decision making, especially for hard-to-quantify problems
- Time-consuming if rigorous, not a substitute for collecting data
- Bayesian Priors
- Model structure
- Scenario development
- Evaluating and weighting forecasts
- Utility and Risk

Expert Elicitation





Biases & Heuristics

- Humans are not innate statisticians
- Rely on mental short cuts (heuristics)
- Systematic patterns to error (biases)
- Challenge of elicitation is to ask experts questions in a way that produces unbiased answers

Anchoring

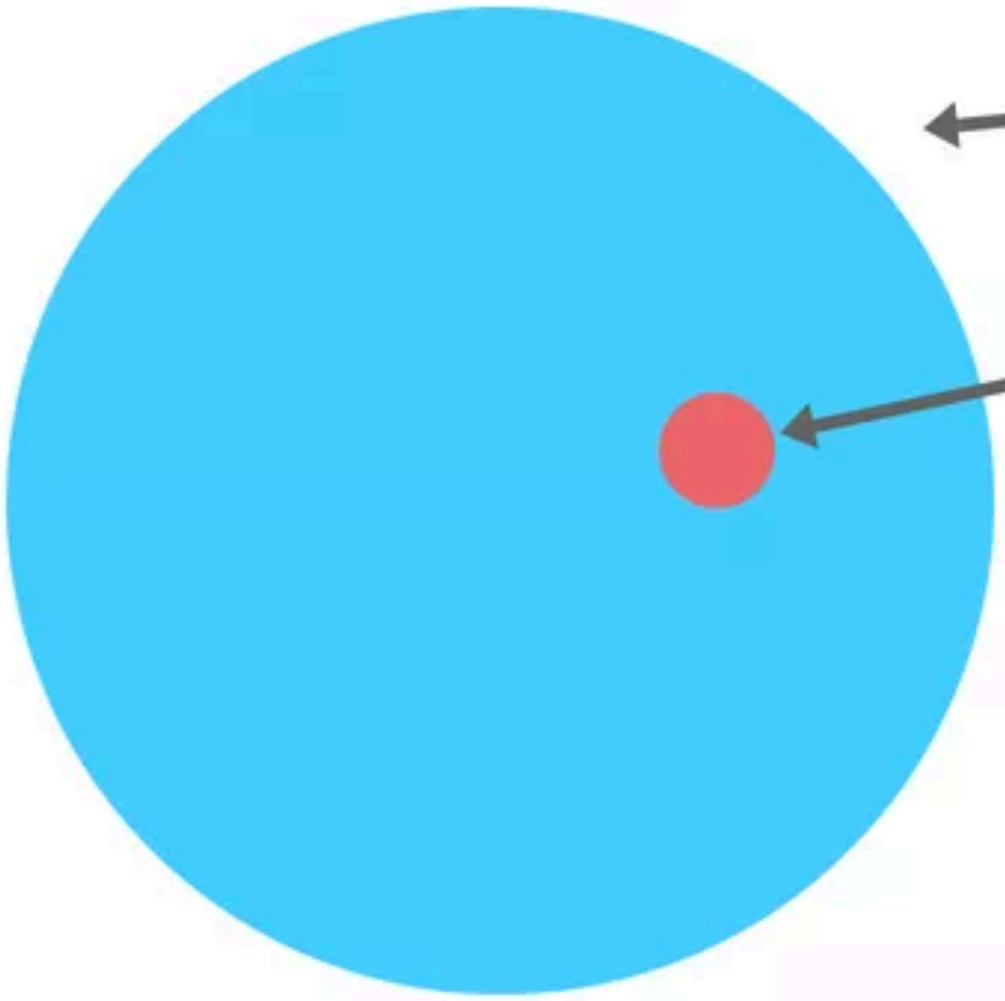
The mind is biased toward the first piece of information

…even if it is irrelevant

Don’t start with the mean / default

last 2 digits of SSN predicts bid on wine

The availability heuristic



All the information

The information you use to make a decision

- recent
- frequent
- extreme
- vivid
- negative

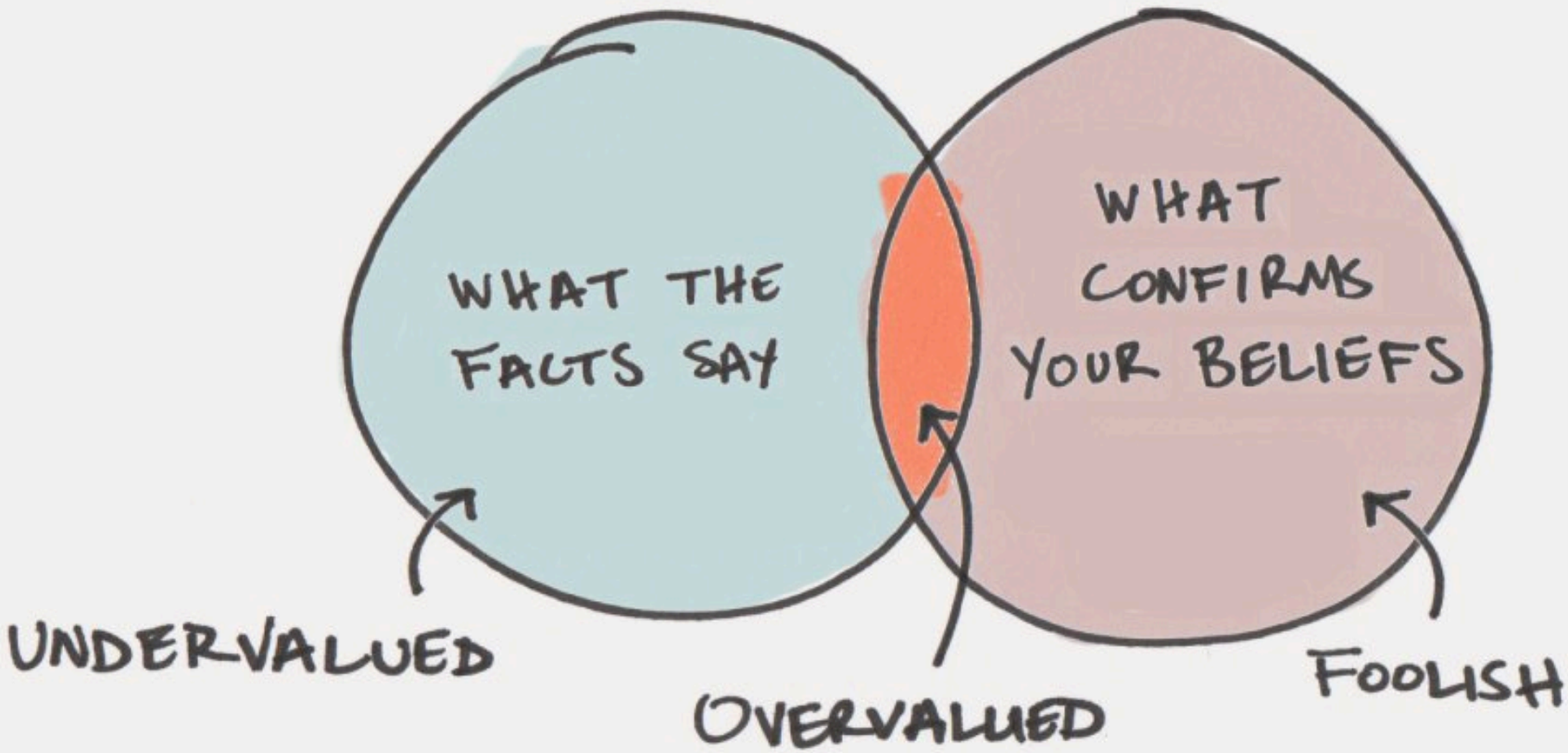
Substitutes ease of recall for frequency

Help expert to not overlook evidence

WHERE DOES THIS PLANE NEED ADDITIONAL ARMOR?

Survivorship bias

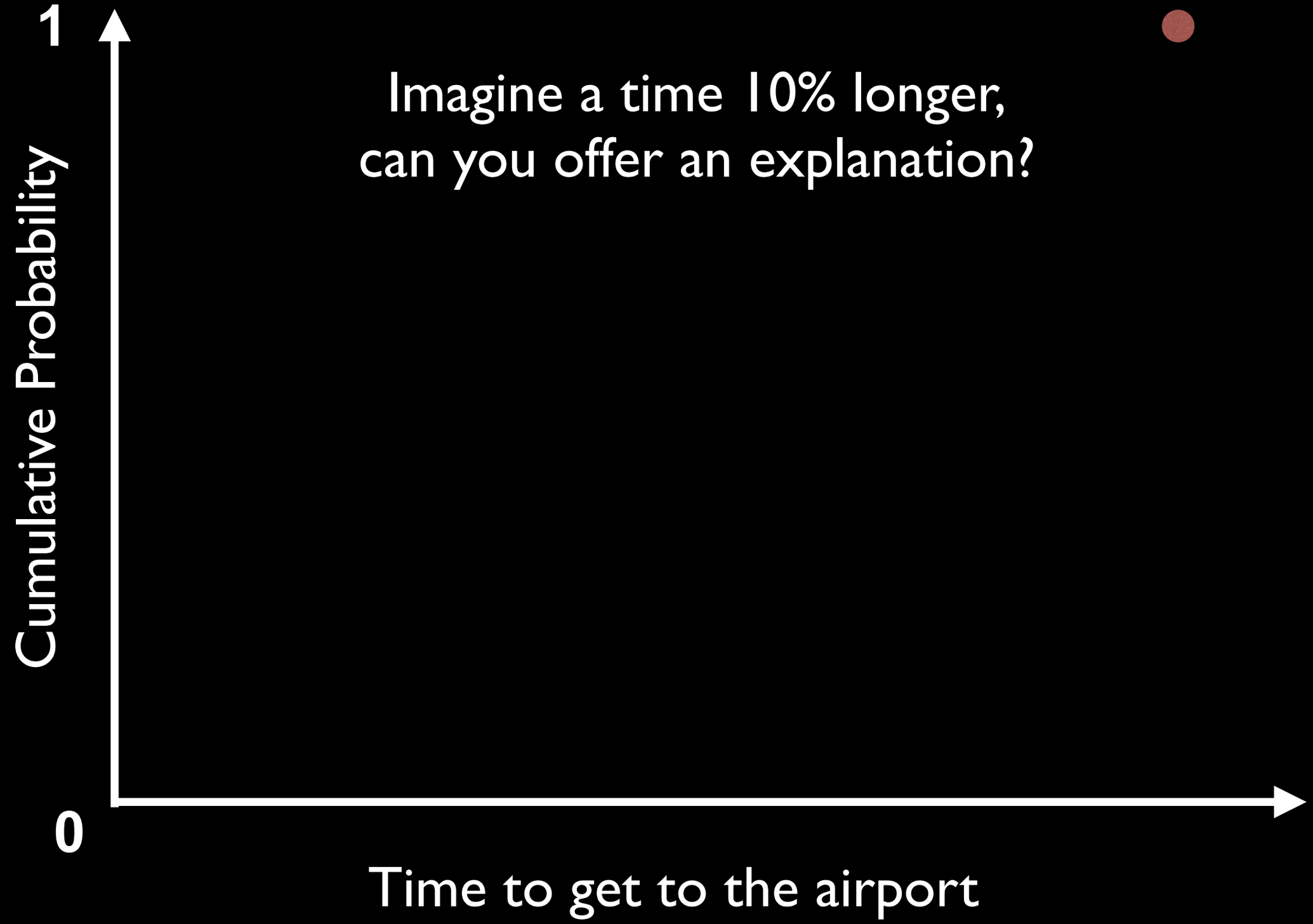
THE CONFIRMATION BIAS



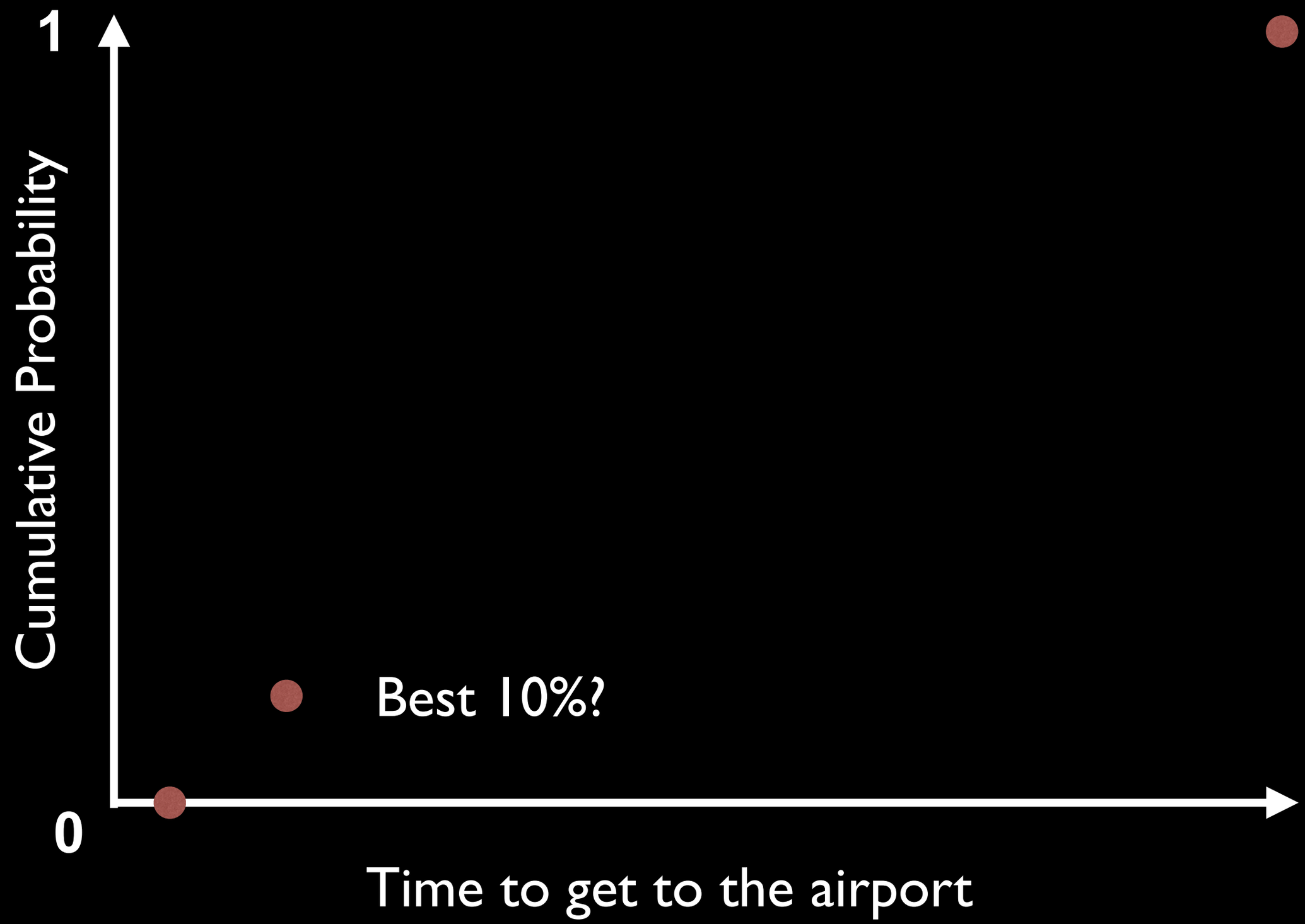
JamesClear.com

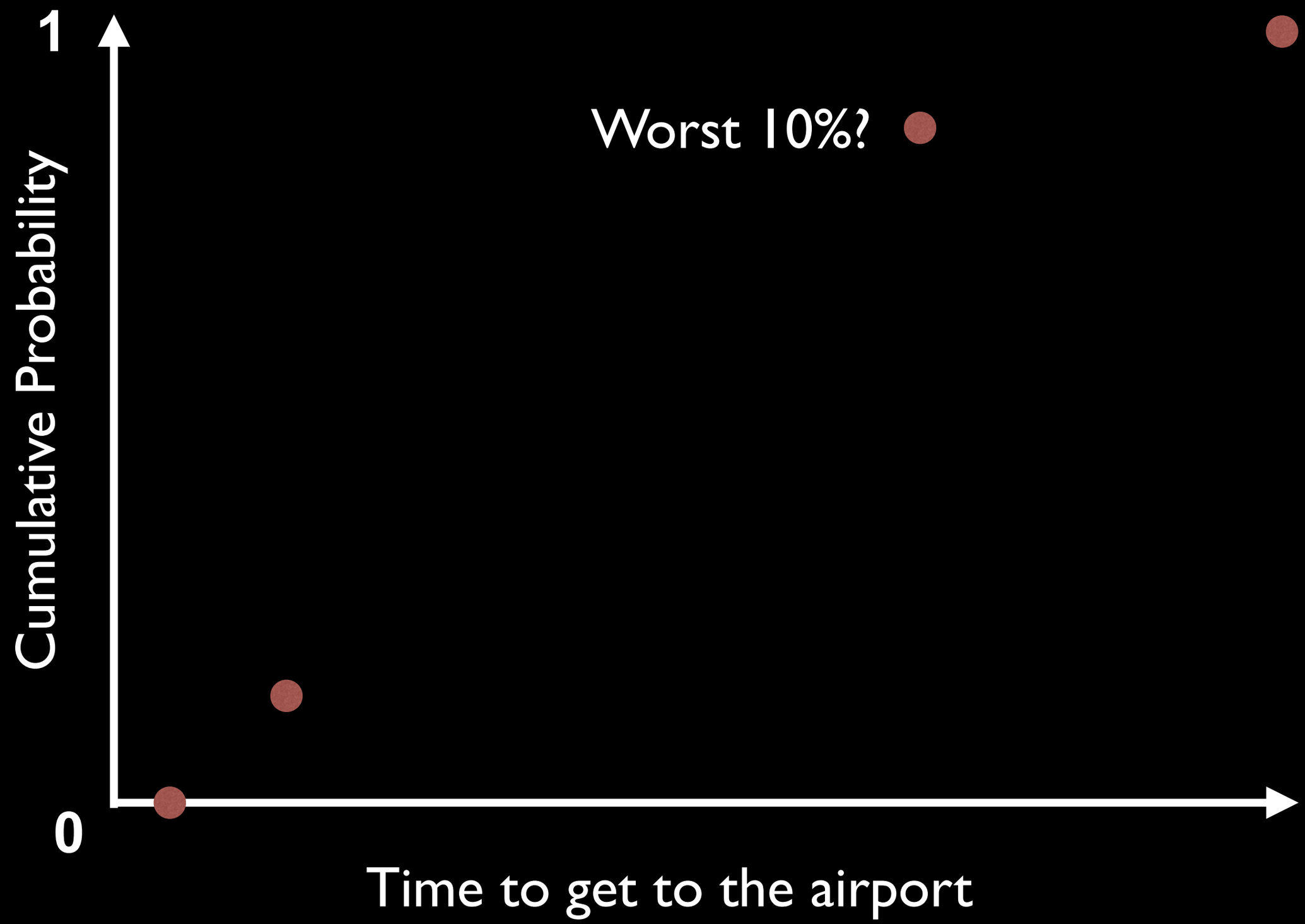
Longest possible time?

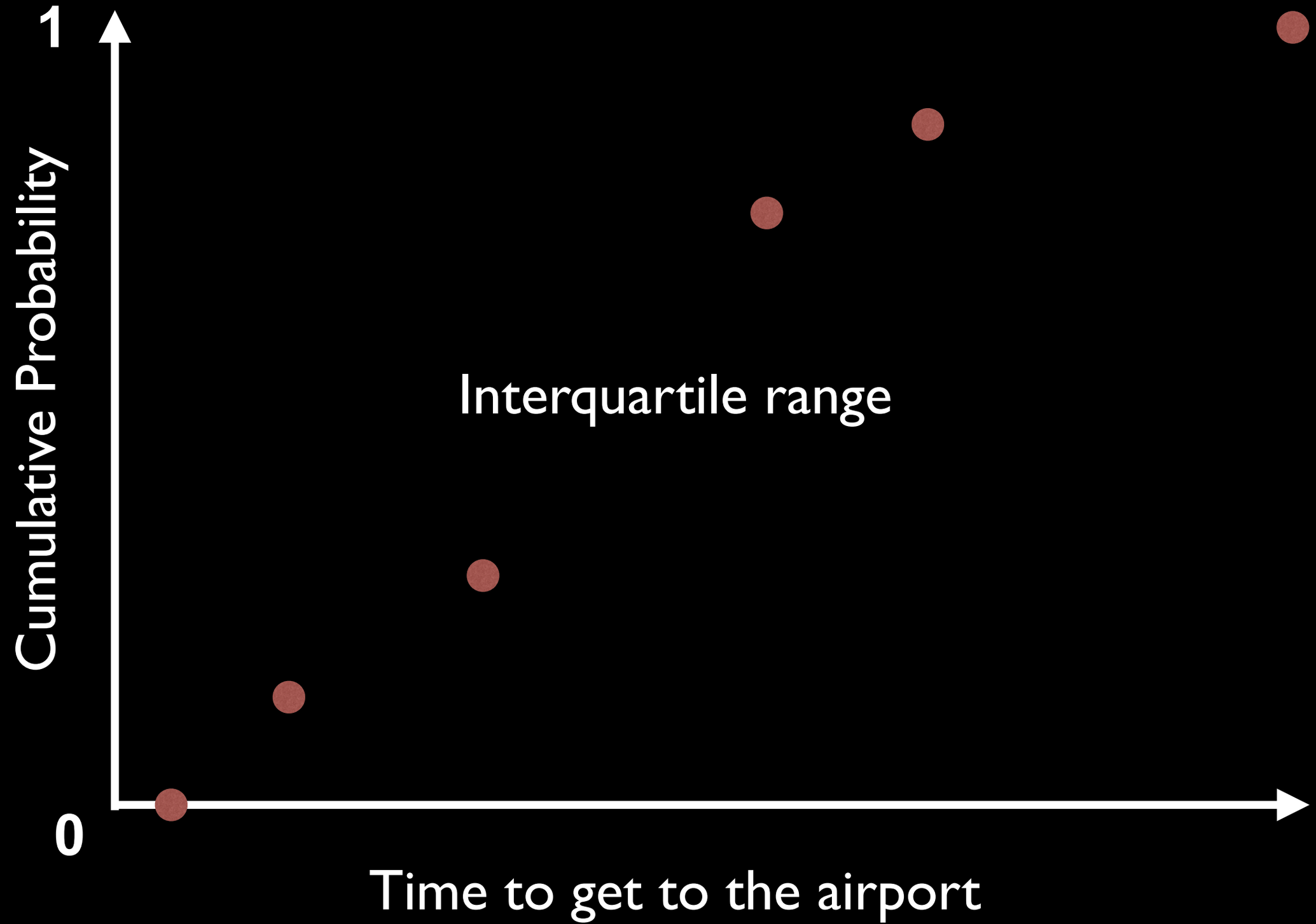
Imagine a time 10% longer,
can you offer an explanation?



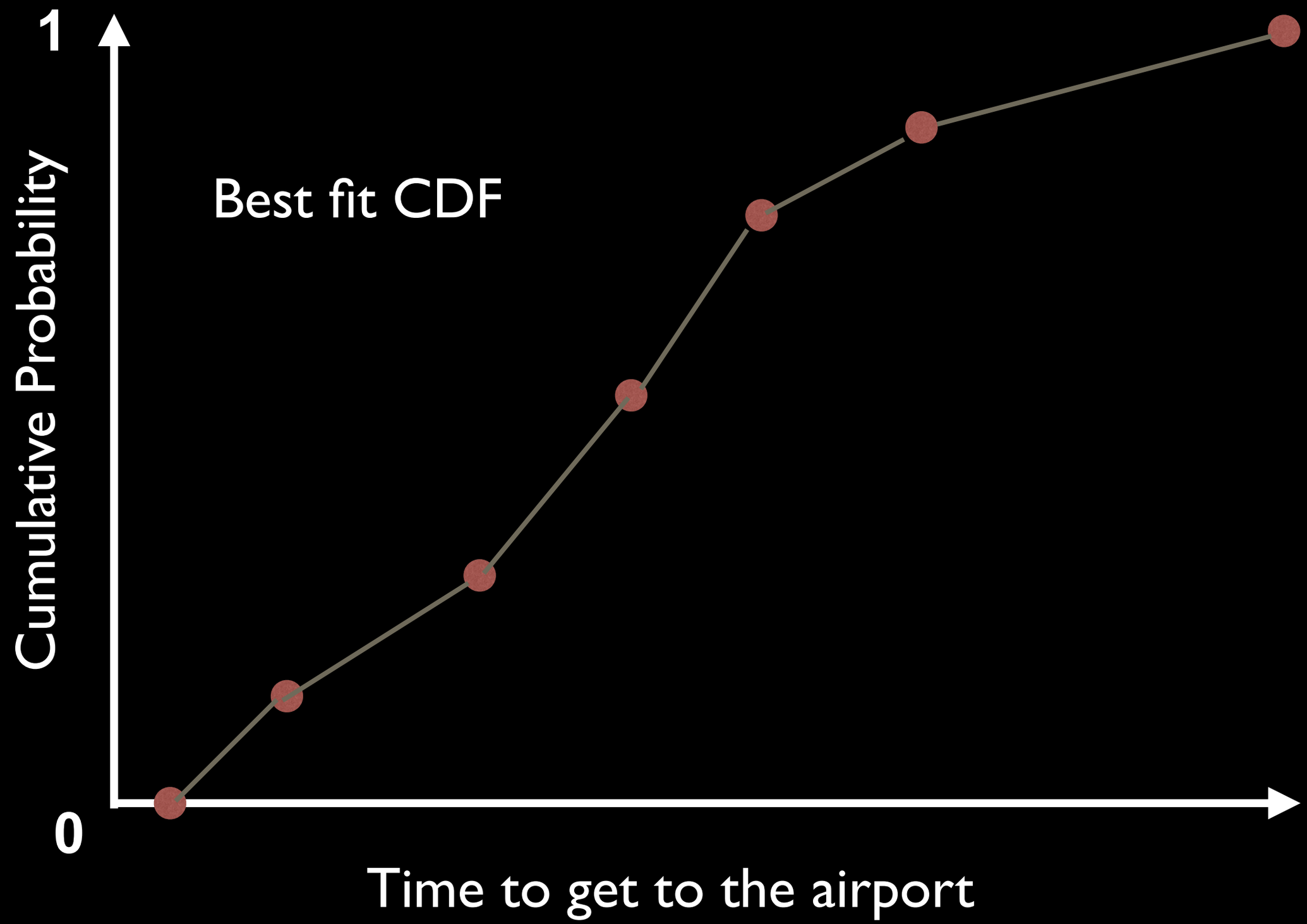

1
Cumulative Probability
0
Shortest possible time?
Time to get to the airport


1
Cumulative Probability
Best 10%?
0
Time to get to the airport


1
Cumulative Probability
Worst 10%?
0
Time to get to the airport


1
Cumulative Probability
Interquartile range
0
Time to get to the airport


1
Cumulative Probability
0
Median (asked last)
Time to get to the airport


1
Cumulative Probability
Best fit CDF
0
Time to get to the airport

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

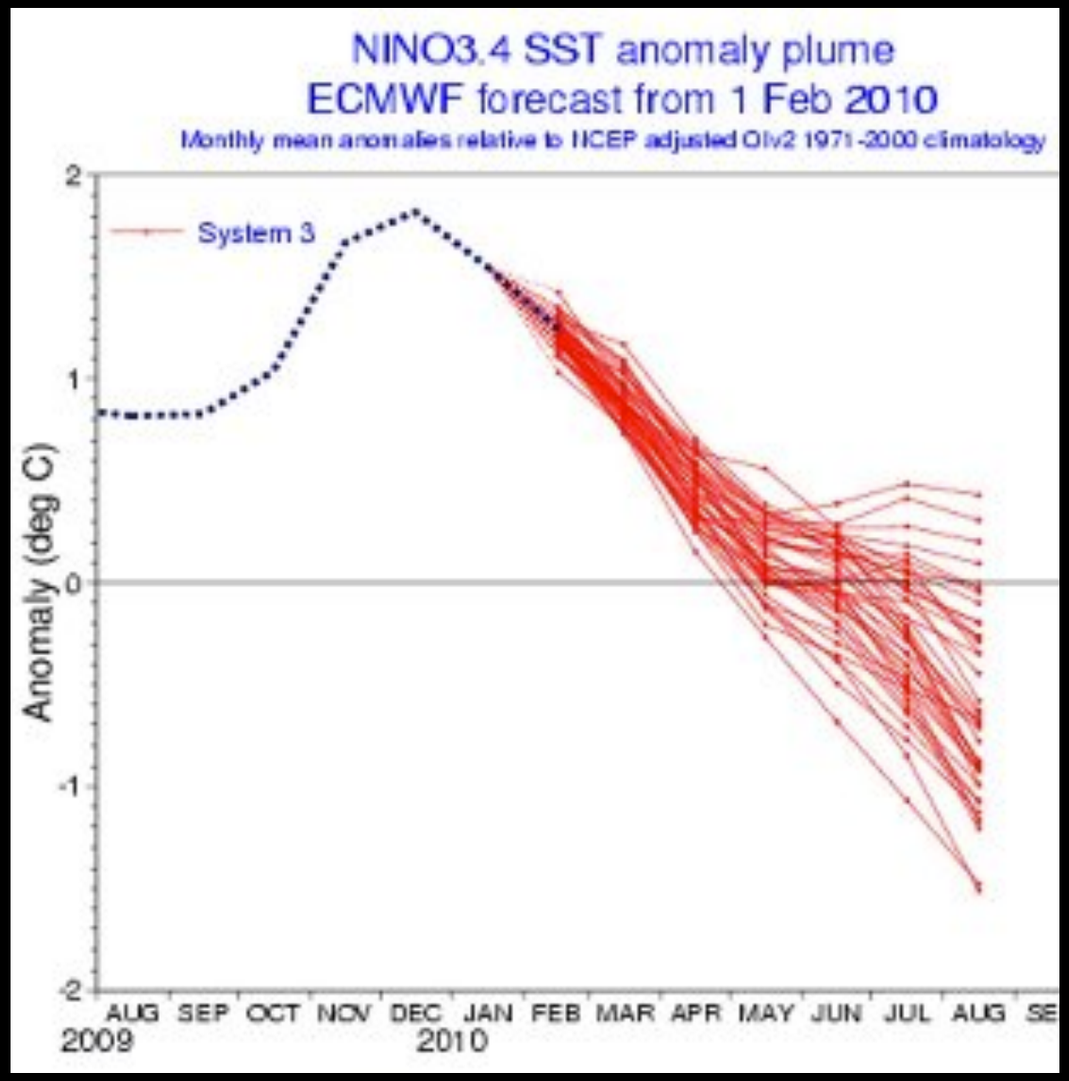
Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1]* Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Science 2008

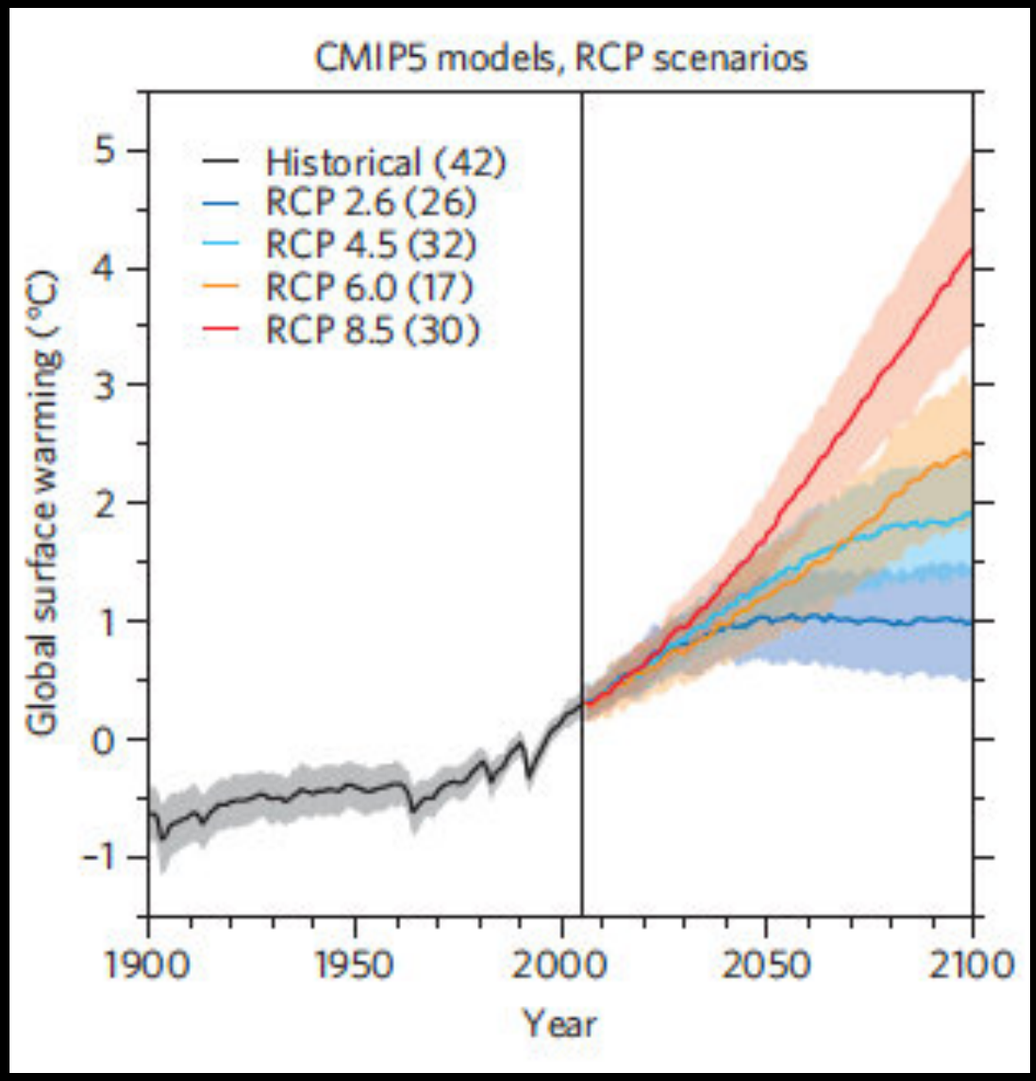
PREDICTION

"PROBABILISTIC STATEMENT THAT SOMETHING WILL HAPPEN IN THE FUTURE BASED ON WHAT IS KNOWN TODAY"



PROJECTION

"PROBABILISTIC STATEMENT THAT IT IS POSSIBLE THAT SOMETHING WILL HAPPEN IN THE FUTURE" GIVEN BOUNDARY CONDITION SCENARIOS



MacCracken 2001

SCENARIOS

Set of plausible **storylines**.
"Futures that could be" that capture key uncertainties
Not probabilistic, don't average over!

Decision alternatives

A framework for addressing low probability events
war games, unknown unknowns, & black swans

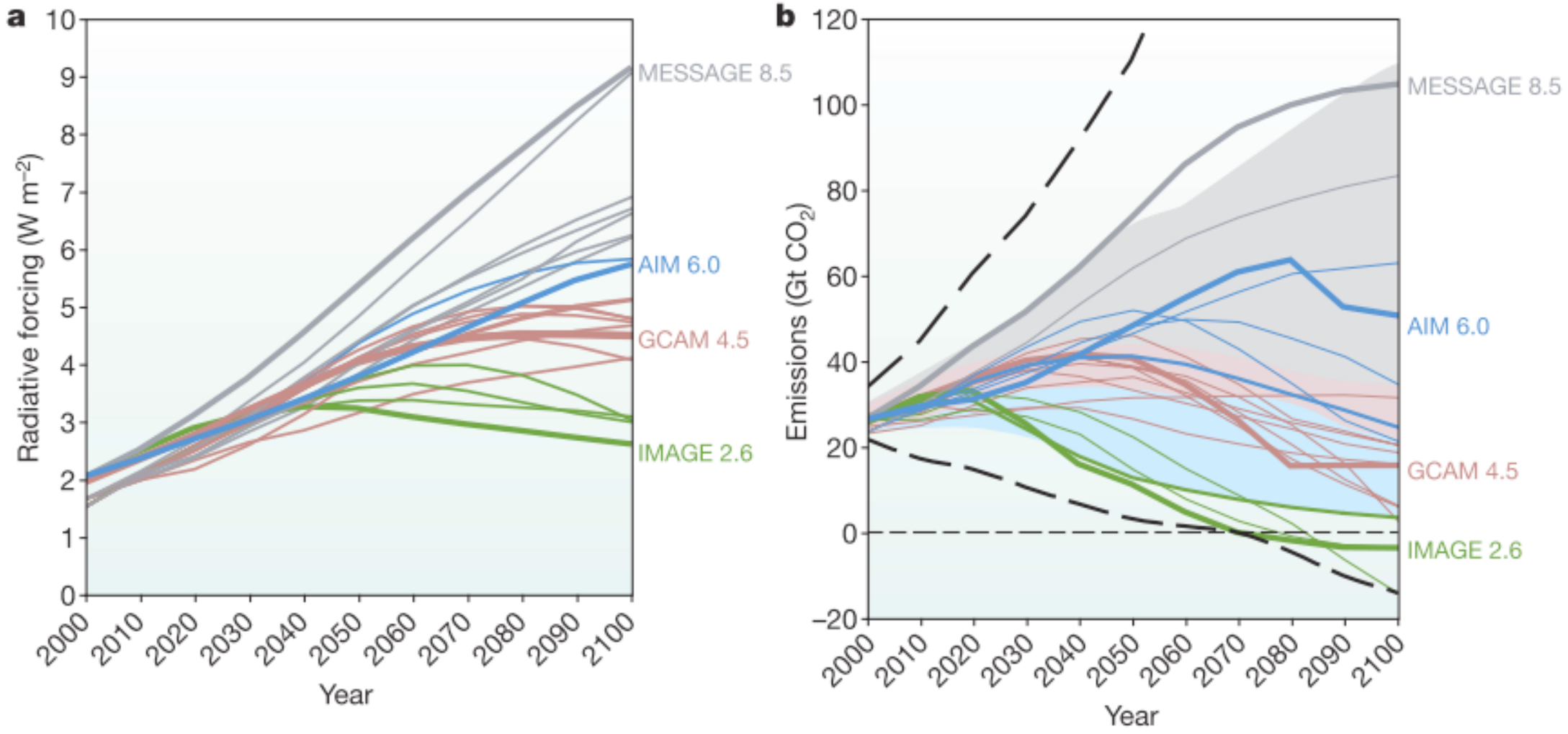


Table 1 | The four RCPs

Name	Radiative forcing	Concentration (p.p.m.)	Pathway	Model providing RCP*	Reference
RCP8.5	>8.5 W m^{-2} in 2100	>1,370 CO_2-equiv. in 2100	Rising	MESSAGE	55,56
RCP6.0	~6 W m^{-2} at stabilization after 2100	~850 CO_2-equiv. (at stabilization after 2100)	Stabilization without overshoot	AIM	57,58
RCP4.5	~4.5 W m^{-2} at stabilization after 2100	~650 CO_2-equiv. (at stabilization after 2100)	Stabilization without overshoot	GCAM	48,59
RCP2.6	Peak at ~3 W m^{-2} before 2100 and then declines	Peak at ~490 CO_2-equiv. before 2100 and then declines	Peak and decline	IMAGE	60,61

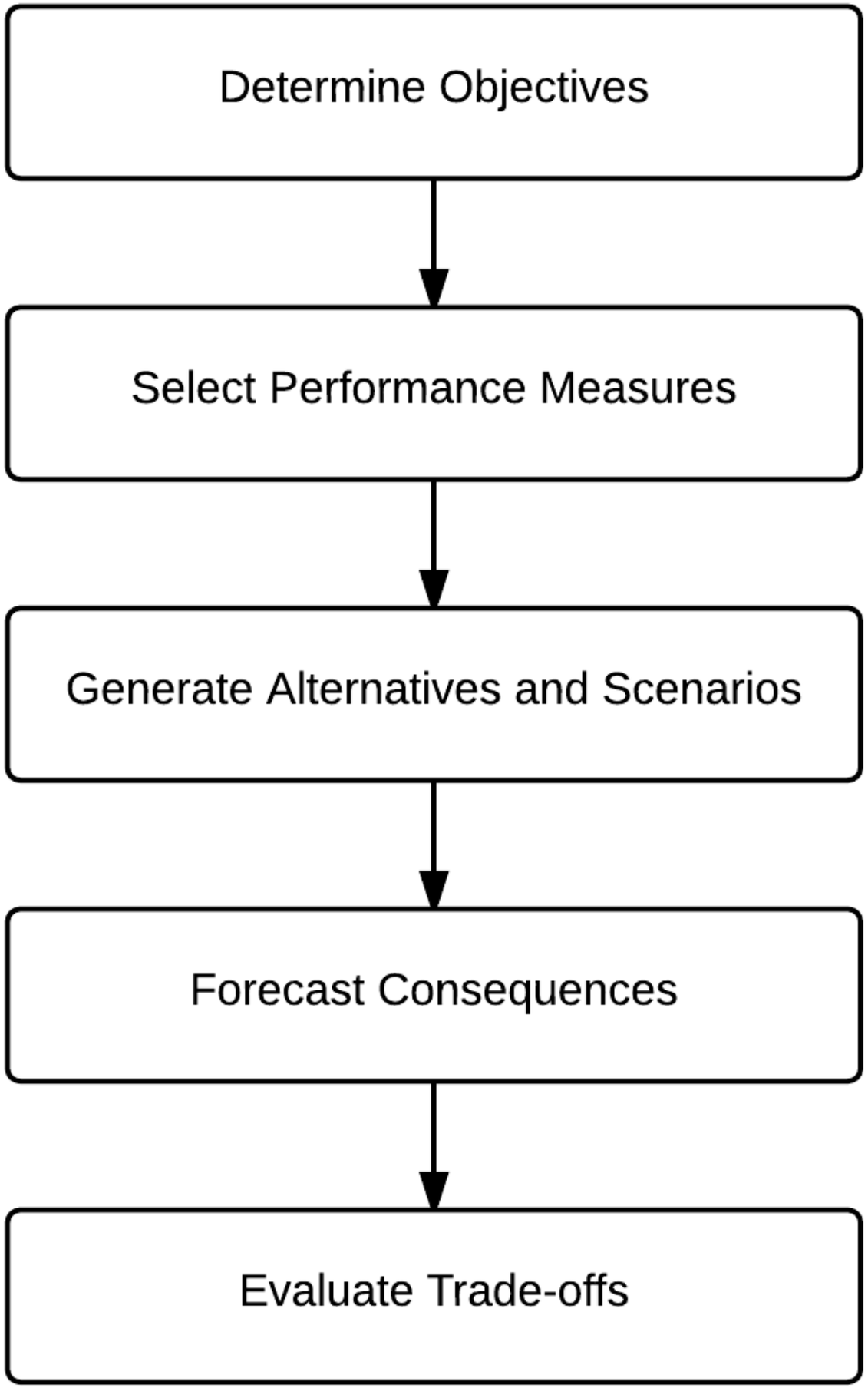
* MESSAGE, Model for Energy Supply Strategy Alternatives and their General Environmental Impact, International Institute for Applied Systems Analysis, Austria; AIM, Asia-Pacific Integrated Model, National Institute for Environmental Studies, Japan; GCAM, Global Change Assessment Model, Pacific Northwest National Laboratory, USA (previously referred to as MiniCAM); IMAGE, Integrated Model to Assess the Global Environment, Netherlands Environmental Assessment Agency, The Netherlands.

Moss et al 2010

DECISION SUPPORT

- Creating well-structured, transparent, and collaborative decision processes involving researchers and stakeholders is as important to effective decision-making as having good scientific information and tools
- Enable decision-makers to apply complex information to decisions,
- Consider uncertainties
- Assess a wide range of possible human responses
- Engage institutions and individuals who are potentially affected

STRUCTURED DECISION MAKING



CONSEQUENCE TABLE

Alternatives

Attribute	Units	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alter
		Name 1	Name 2	Name 3	Name 4	Name 5	Nam
Unit Energy Cost	$/MWh	149	114	110	124	108	
GHG Emissions	kilotons/yr CO2e	31	8	8	16	8	
Local Air Emissions	tons/yr (PM10)	16	17	21	9	24	
Land Area	m2 (000)	29.7	16.8	4.6	19.6	3.1	
Aquatic Area	m2 (000)	8	24	-	35	20	
Construction Jobs	Person-years	75	119	105	96	119	
Permanent Jobs	FT equivalent	49	81	83	76	84	
Noise	Weighted Average Scale (0=Best, 10=Worst)	6.7	3.1	3.7	3.6	3.9	
Visual Impacts	Weighted Average Scale (0=Best, 10=Worst)	1.5	2.2	2.8	1.4	2.2	
Food Harvesting Areas	Weighted Average Scale (0=Best, 10=Worst)	1.5	0.9	0.5	1.4	0.2	
Sustainability / Innovation	Weighted Average Scale (10=Best, 0=Worst)	-	0.3	0.5	0.7	0.3	
Sustainability / Innovation	% Dependable Peak Provided By Renewables	12%	22%	23%	12%	25%	

Objective

Performance Measure

Consequences

STAKEHOLDER WORKSHOPS

- Should engage a diverse group of stakeholders
  - Need for multiple points of view when considering complex environmental issues
- Allows people to step away from entrenched positions and identify positive futures
- Biggest trap is the inability of participants to perceive their own assumptions and the potential consequences of being wrong

OBJECTIVES

- Summarize something that matters to the stakeholders (e.g. fisheries revenue)
- Inclusion validates that an objective has value, but stakeholders may disagree on how much
- Not assigned weights
- Desired direction of change (not goal/threshold)
- Context-specific, not statements about universal values

DECISION: TRAVEL TO NYC

OBJECTIVE	
MIN TIME	
MIN COST	
MIN CO2	
MAX COMFORT	

PERFORMANCE MEASURES

- Quantify objectives
  - Natural (e.g. carbon storage MgC/ha)
  - Proxy (e.g. habitat quality)
  - Constructed measures (1-10), defined impact scales
- Natural units, don't have to monetize
- All values for a single performance measure (row) need to be calculated the same way with the same assumptions

REPORTING UNCERTAINTIES

- Difference between common and technical language
- Humans do not innately understand probability
  - But are accustomed to dealing with risk
- Report more than mean, but not piles of stats
  - CI interpreted as equal probability
  - multiple framings: 5% vs 1 in 20
  - low probabilities are ignored, focused on outcome

FRAMING UNCERTAINTIES

- Reference baselines
  - but losses and gains not perceived equally
- Downside reporting: worst plausible case
- Exceedance probability

DECISION: TRAVEL TO NYC

OBJECTIVE	MEAS.
MIN TIME	hr
MIN COST	US$
MIN CO2	lbs
MAX COMFORT	stars (1-5)

ALTERNATIVES

- Any decision is only as good as the set of alternatives considered
- Search for win-win alternatives: iterative, hybridization
- How many?
  - Initial: computational, financial, time limits
  - Stakeholders: 4-12
  - Decision: 3-4

  } Even numbers reduce anchoring on middle

- Unbiased, informative names

COGNITIVE BIASES

- Anchoring & adjustment: reference to initial (status quo)
  - Bookend strategies
- Representativeness (similarity to sterotype; misweight disconfirming/ irrelevant)
- Availability (giving more weight to recent examples)
- Sunk cost
- Groupthink: premature consensus

ALTERNATIVE CRITERIA

- Address the same problem
- Evaluated over the same time
- Same level of detail
- Same assumptions and performance metrics
- Mutually exclusive
- Able to drive forecast models

MANAGING RISK

- Precautionary Alternatives
  - but can't be precautionary for all objectives
- Robust Alternatives
- Adaptive Alternatives
  - Iterative forecasting
- All come with a cost!

DECISION: TRAVEL TO NYC

OBJECTIVE	MEAS.	CAR	CAR POOL	BUS	TRAIN	PLANE
MIN TIME	hr					
MIN COST	US$					
MIN CO2	lbs					
MAX COMFORT	stars (1-5)					

ESTIMATING CONSEQUENCES

- Ecological Forecasting!
- First pass: Expert elicitation, literature, Fermi estimation
- Focus on terms that affect the outcome of the decision
  - Uncertainty analysis
  - Reducible vs irreducible uncertainties

DECISION: TRAVEL TO NYC

Alternatives

OBJECTIVE	MEAS.	CAR	CAR POOL	BUS	TRAIN	PLANE
MIN TIME	hr	8.5	8.5	9.5	9.5	4.25
MIN COST	US$	107	26	80	166	195
MIN CO2	lbs	240	60	15	110	125
MAX COMFORT	stars (1-5)	3	3	3	3.5	3.5

Consequences

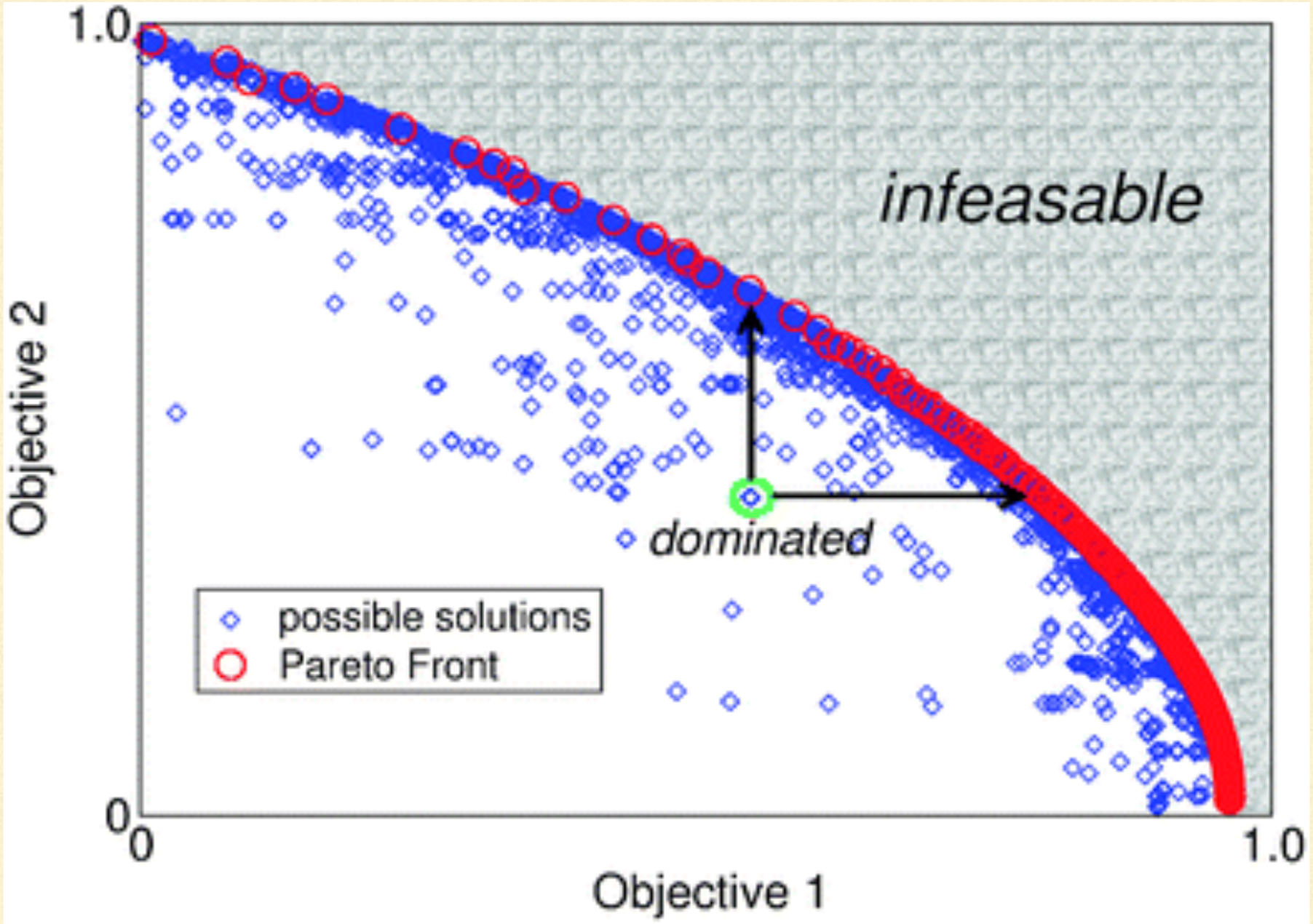
TRADE-OFFS

- If no clear winner, goal is to eliminate **dominated** Alternatives and **insensitive** Performance Measures
- Refine understanding of key trade-offs
- Strictly vs practically dominated
  - Not based on CI!!
- By hand for small n
- No regrets actions

Dominated

OBJ.	MEAS	CAR	CAR POOL
MIN TIME	hr	8.5	8.5
MIN COST	US$	107	26
MIN CO2	lbs	240	60
MAX COMFORT	stars (1-5)	3	3

PARETO OPTIMIZATION



DECISION: TRAVEL TO NYC

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DECISION: TRAVEL TO NYC

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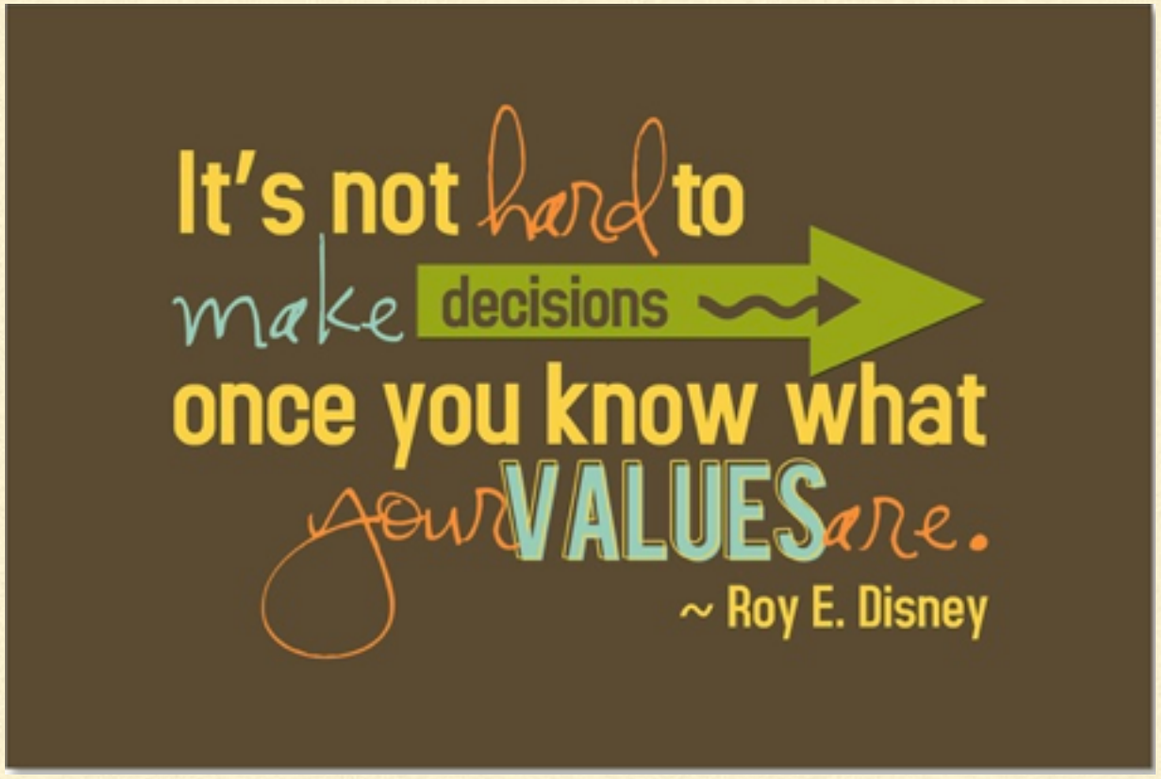
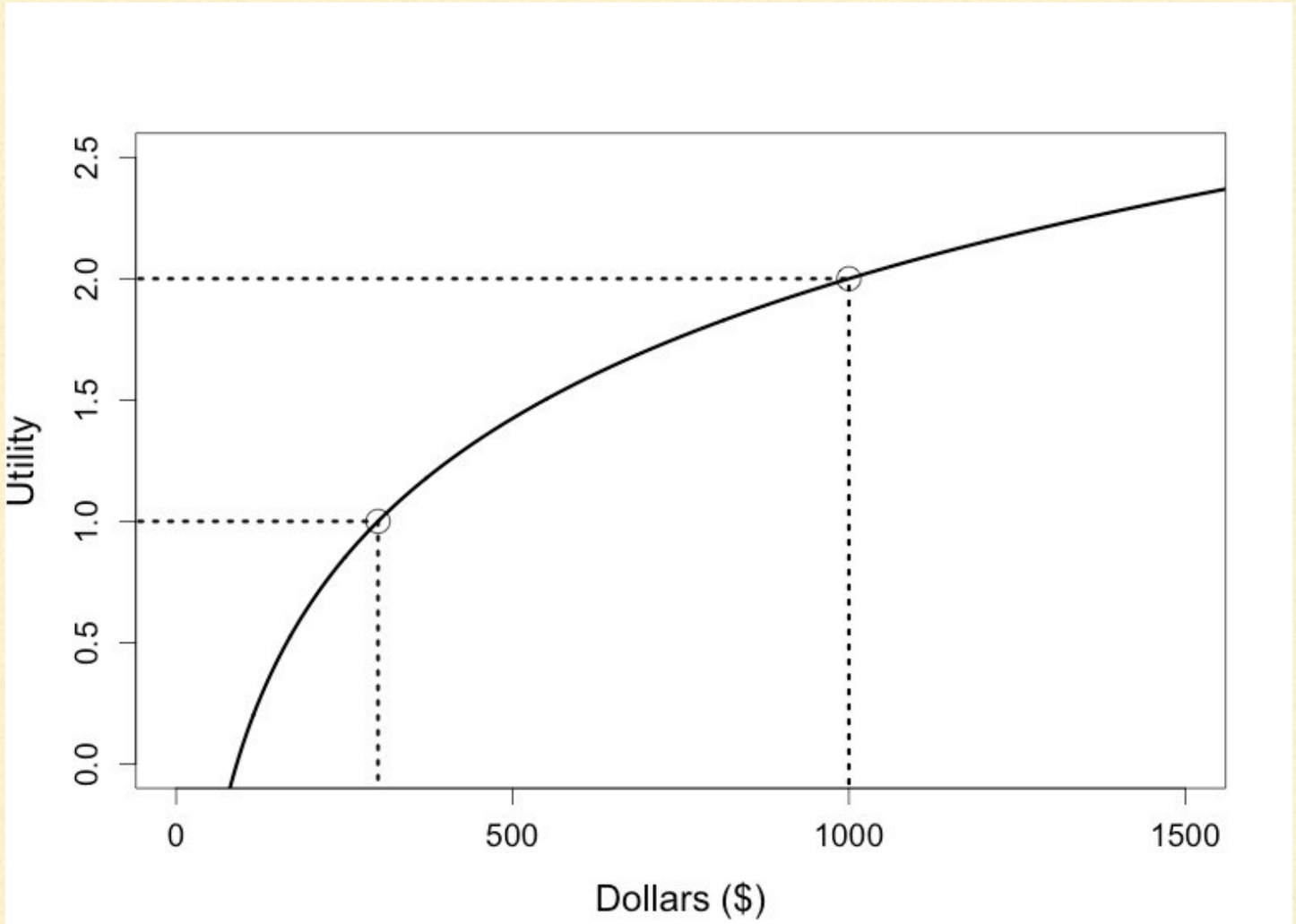
VALUES

- Consequence table organizes information
- Decisions are about values
  - beliefs
  - priorities & preferences
  - tolerance for risk
  - time discount



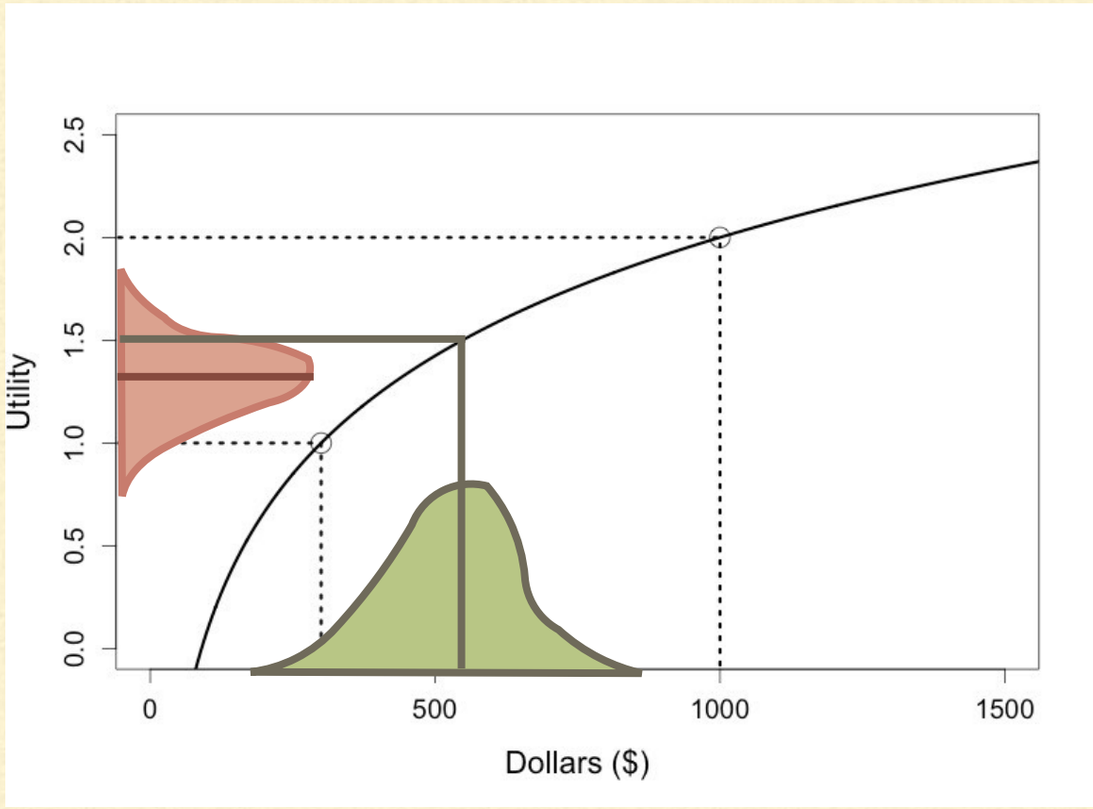
UTILITY

- Cumulative value increases
- Marginal value decreases
- Maximum Willingness to Pay
- Demand = Marginal MWTP
- Eliciting indifference



RISK TOLERANCE

- Losses hurt more than gains
- Concave = risk adverse
- E[U(x)] < U(E[x])
- E[U(x)] declines with increasing uncertainty
- More risk neutral for repeated, low-stakes decisions



WEIGHTING OBJECTIVES

- Only done AT END: post winnowing, data in hand
- Done at individual level: Jensen's Inequality; How trade-offs perceived
- Swing weighting, ranking (best=100) vs Utility
- Sensitivity & Critical value analysis
  - How much would Consequence have to change?

VALUE OF INFORMATION

- "When does the addition of more information contribute to decision-making so that the **benefit of obtaining this information exceeds the expense of collecting and processing it**?"

- Expected additional benefit from additional information, relative to what could be expected without that information

- Delaying a decision to obtain more information doesn't always lead to different or better decisions

DECISION SUPPORT