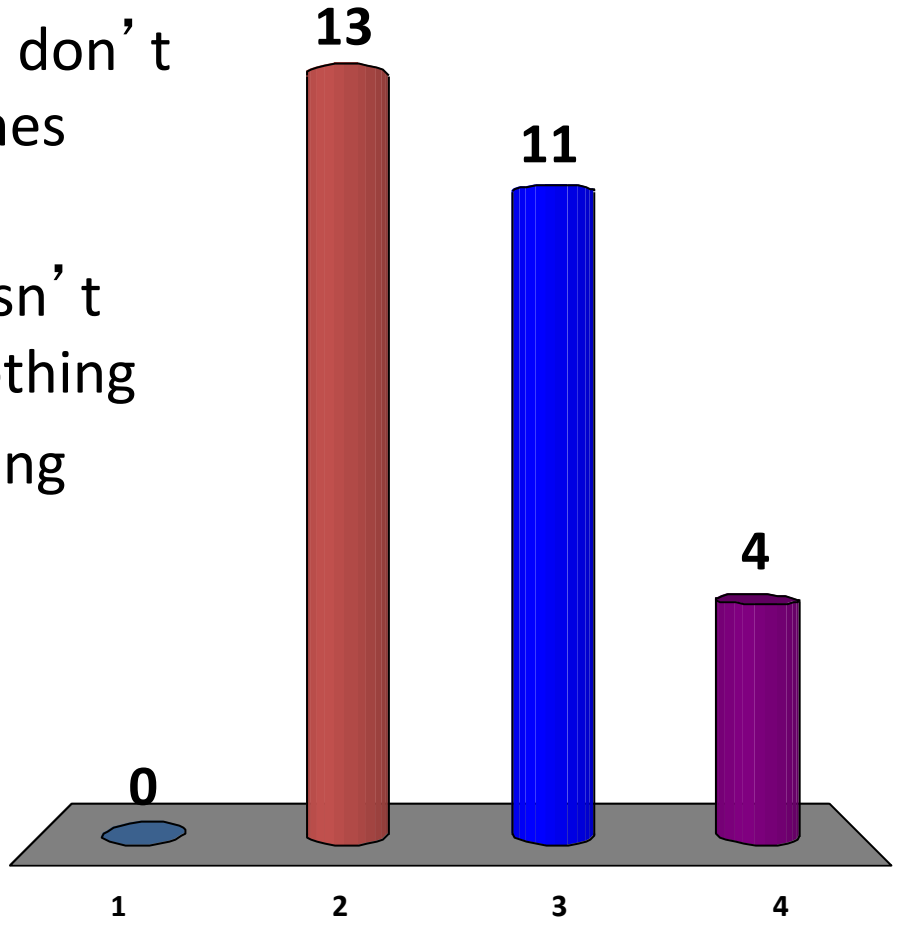
What is the most likely response at your office when key data gaps are encountered during a decision-making process?

1. We don't move forward; we don't want to compromise outcomes with inadequate data
2. We find substitute data—it isn't ideal, but it's better than nothing
3. We make acquiring the missing data a higher priority
4. Other



Your pet is sick

9 of 10 vets say it will die without treatment

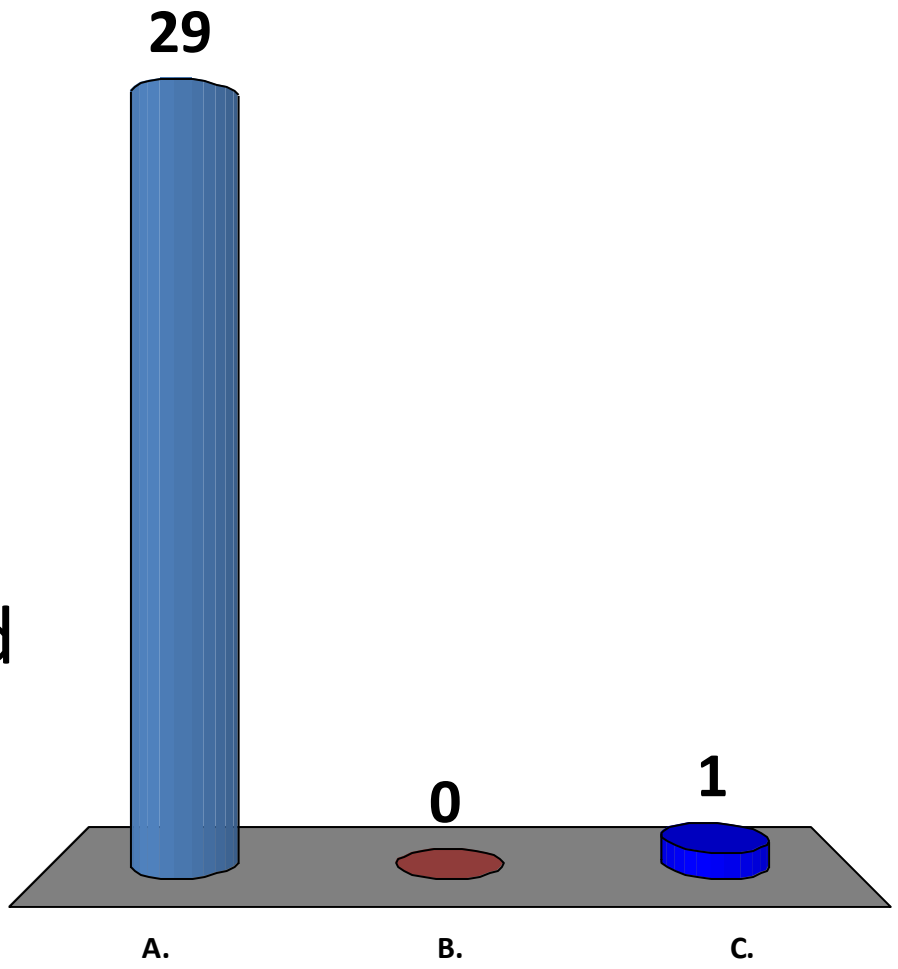
The treatment is established, effective, has few side effects and is affordable.

Do you opt for:

A. Giving it the drug

B. Not giving it the drug

C. Trying an herbal remedy that worked for a friend's pet



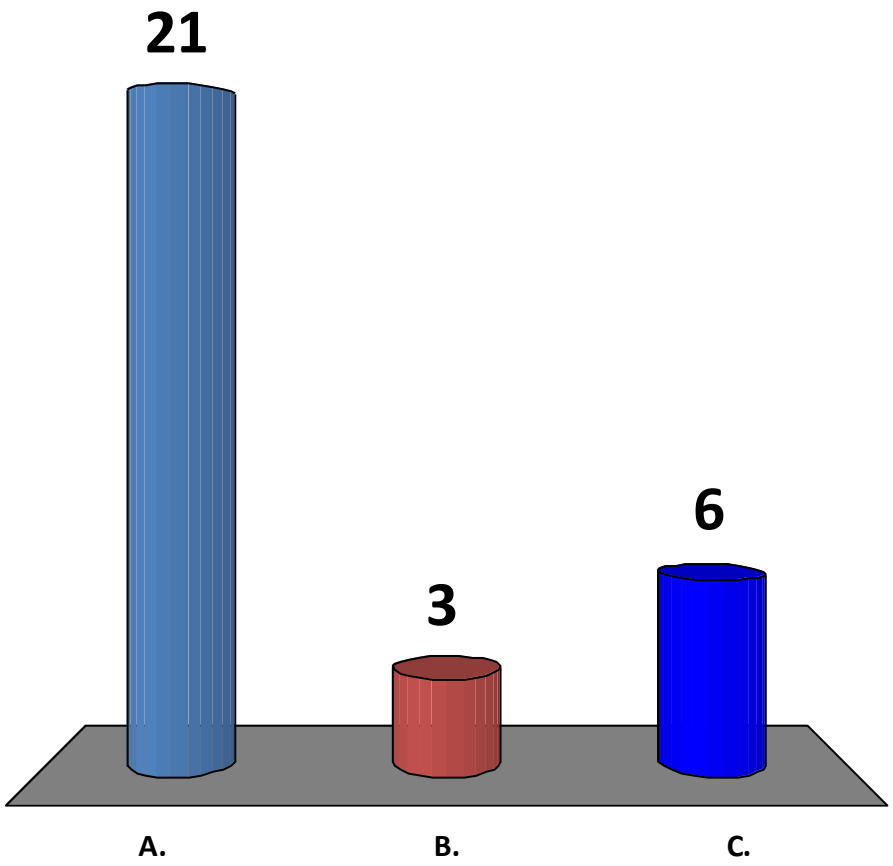
Your pet is sick

4 of 10 vets say it will die without treatment

The treatment is established, effective, has few side effects and is affordable.

Do you opt for:

A. Giving it the drug
B. Not giving it the drug
C. Trying an herbal remedy that worked for a friend's pet



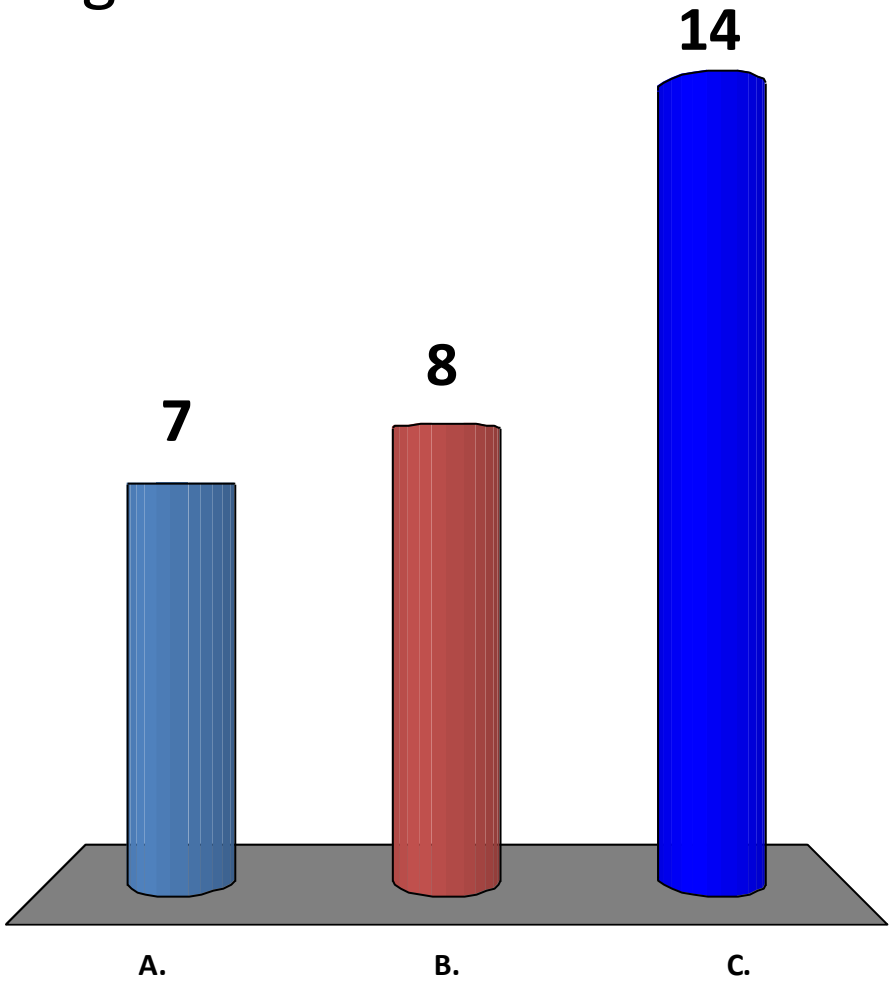
Your pet is sick

9 of 10 vets say it will die without treatment

There is no proven treatment, but there's an expensive experimental drug with uncertain risks and effectiveness.

Do you opt for:

A. Giving it the drug
B. Not giving it the drug
C. Trying an herbal remedy that worked for a friend's pet



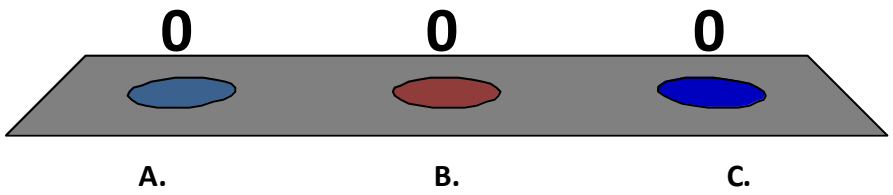
Your pet is sick

4 of 10 vets say it will die without treatment

There is no proven treatment, but there's an expensive experimental drug with uncertain risks and effectiveness.

Do you opt for:

A. Giving it the drug
B. Not giving it the drug
C. Trying an herbal remedy that worked for a friend's pet



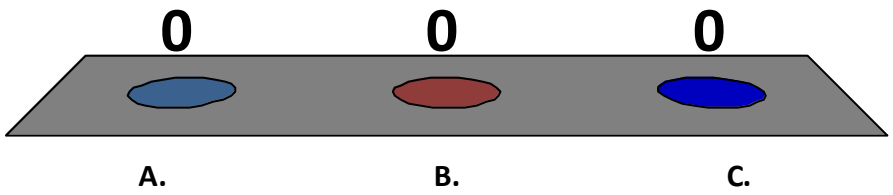
Your child is sick

9 of 10 doctors say she will die without treatment

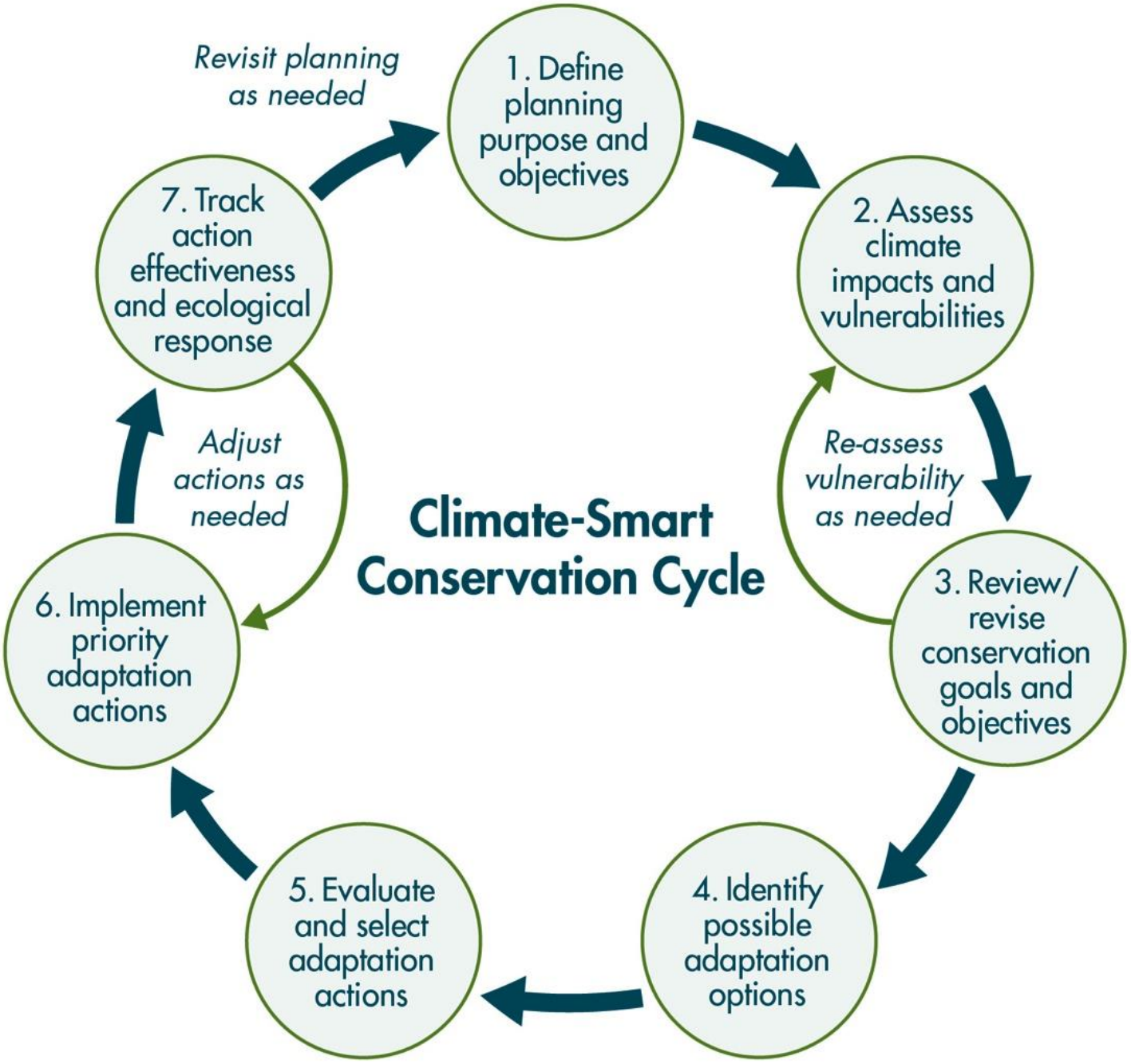
There is no proven treatment, but there's an expensive experimental drug with uncertain risks and effectiveness.

Do you opt for:

A. Giving her the drug
B. Not giving her the drug
C. Trying an herbal remedy that worked for a friend's child



Putting Uncertainty in Context


Climate-Smart Conservation Cycle
1. Define planning purpose and objectives
2. Assess climate impacts and vulnerabilities
3. Review/ revise conservation goals and objectives
4. Identify possible adaptation options
5. Evaluate and select adaptation actions
6. Implement priority adaptation actions
7. Track action effectiveness and ecological response
Revisit planning as needed
Re-assess vulnerability as needed
Adjust actions as needed

Responses to uncertainty

Responses to uncertainty

- Ignore it/pretend you've gotten rid of it

Beware spurious precision!

Certain: death and taxes

Uncertain: everything else

Responses to uncertainty

- Wait for more certainty before taking action

Responses to uncertainty

- Frame the problem as one of uncertainty

"Will this help us get out in front of the climate change ball? Or will we spend so much time analyzing and doing more research that we lose critical time before implementation can happen?"

Responses to uncertainty

- Focus on better-understood problems where uncertainty seems manageable

Responses to uncertainty

- Understand and work with it

May I have the ability to reduce the uncertainties I can, the willingness to work with the uncertainties I cannot, and the scientific knowledge to know the difference.

Joe Barsugli, Cheis Anderson, Joel Smith and Jason Vogel

Reducibility

- Future greenhouse gas emissions

vs

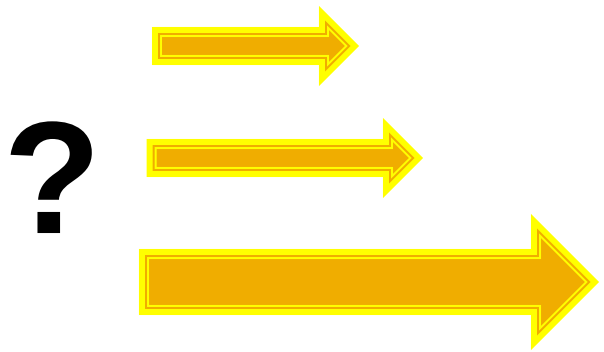
- How global temperatures respond to increases in GHG concentration

vs

- How global precipitation regimes respond to increases in GHG concentration

Directionality vs. magnitude

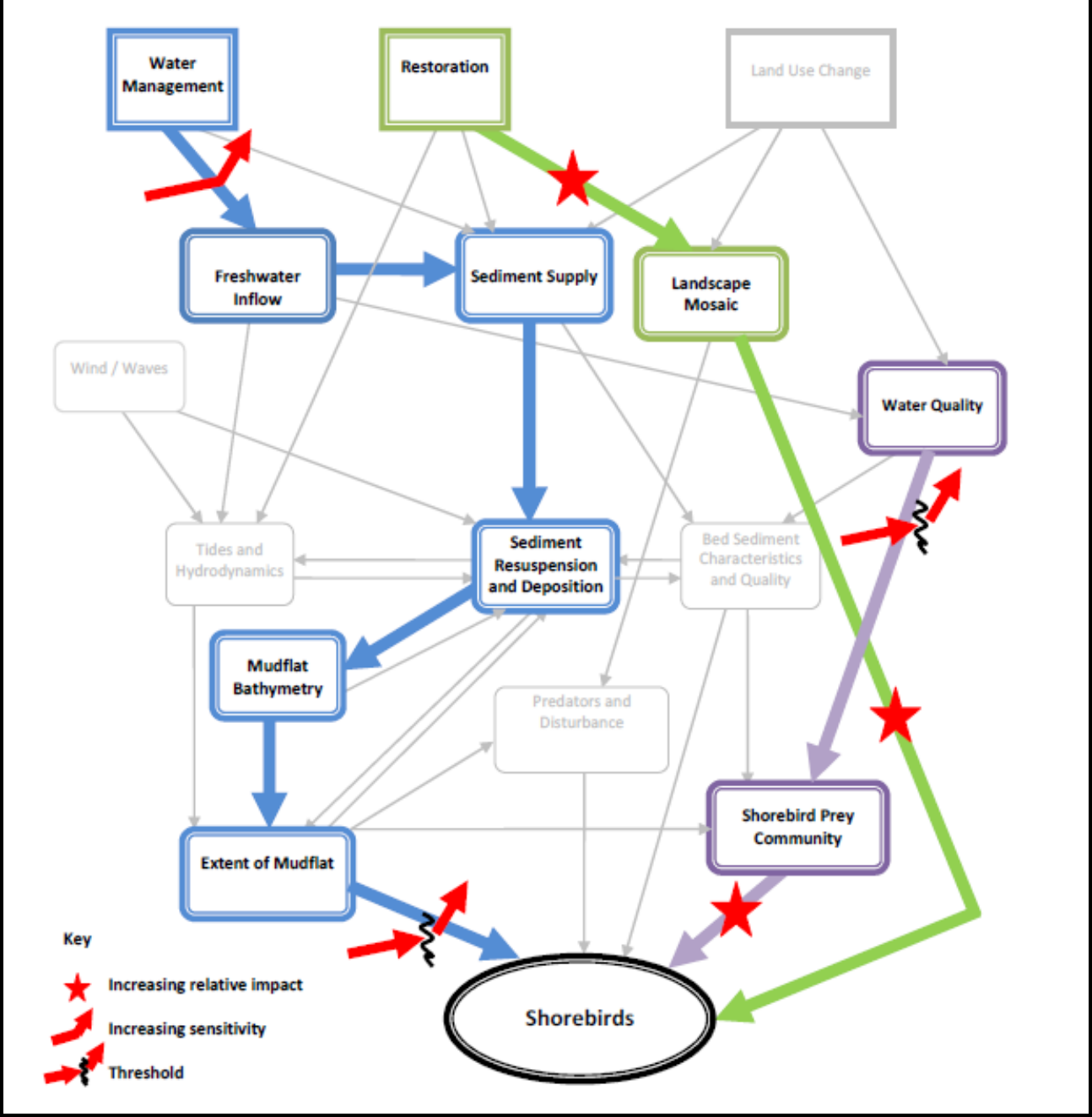
- All climate models say things will get warmer; they disagree on just how much warmer
- Models disagree on whether things get wetter or drier overall



Surf the wave!

- Expert elicitation
- Scenario planning
- Adaptive management
- Decision sensitivity analysis/value of information analysis

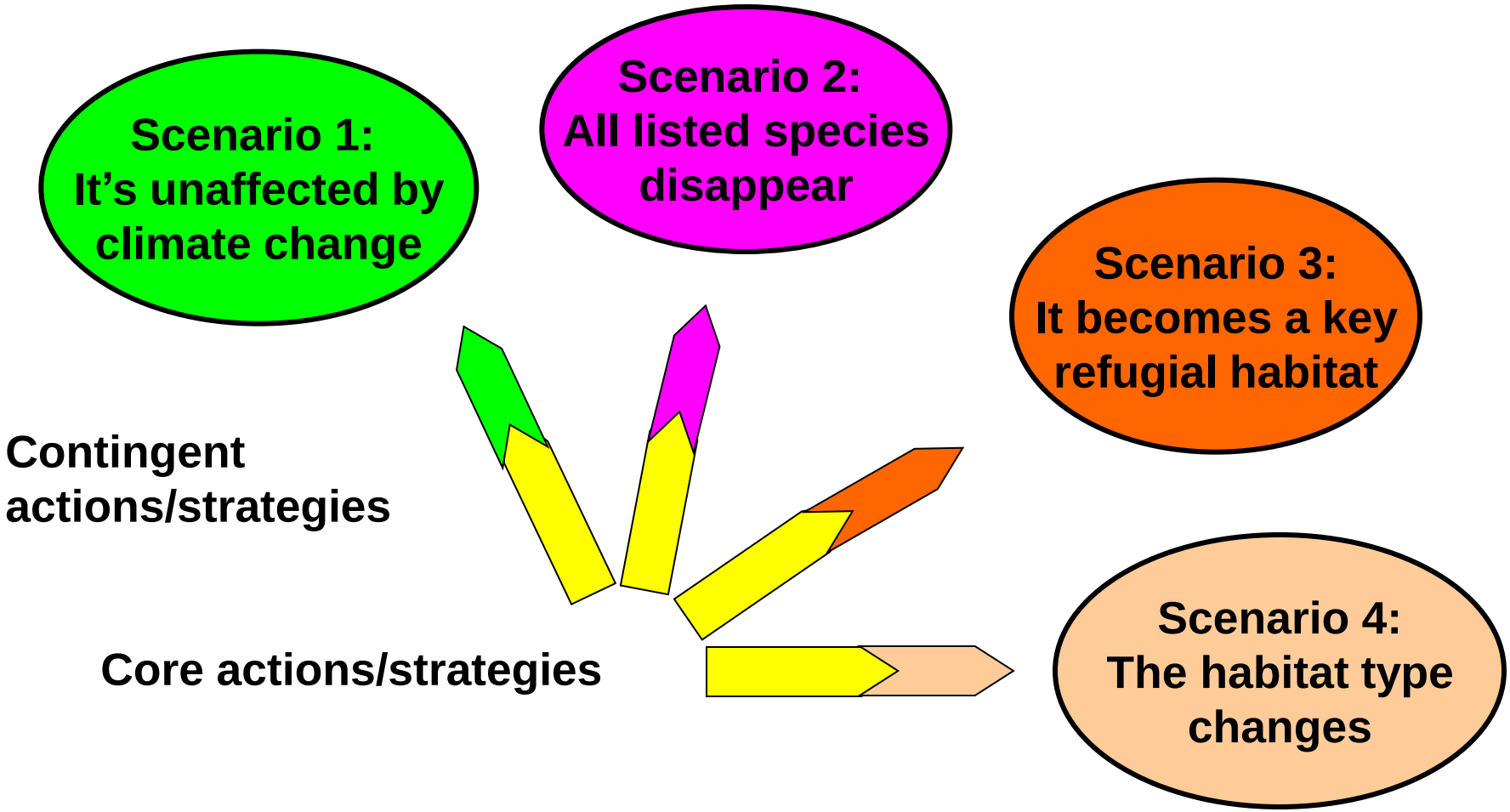
Climate Ready Estuaries "EE-type exercise"



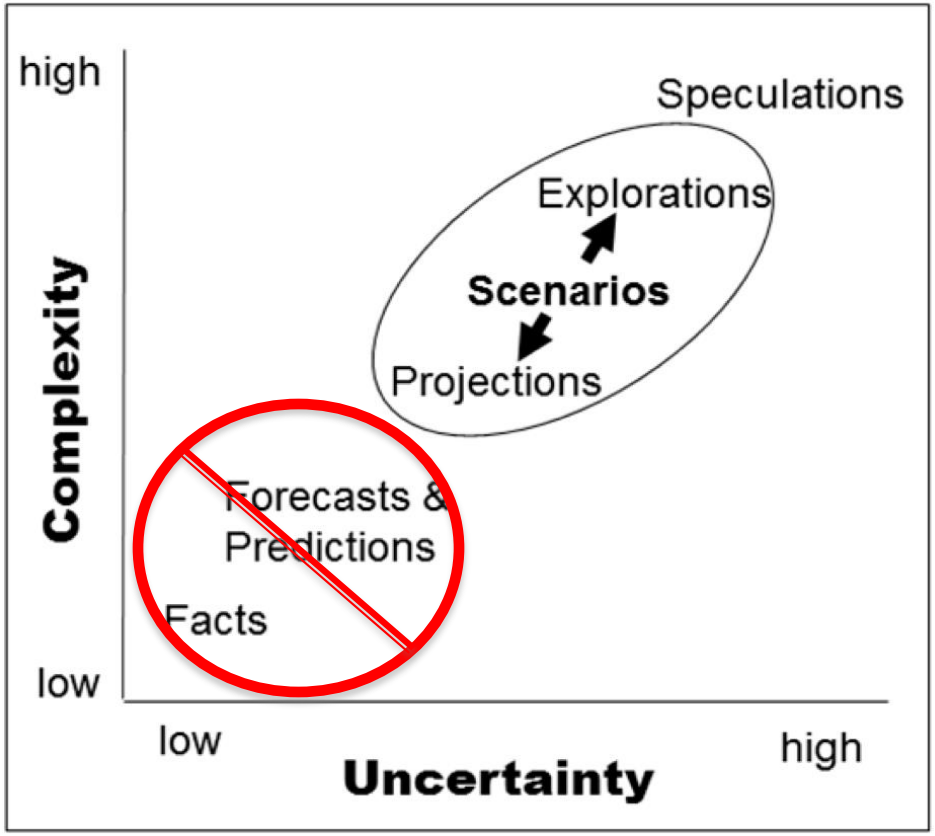
Scenario planning and robust decision-making,

or

Should I buy this piece of property?



What are scenarios?



Adapted from Zurek and Henrichs, 2007

Driving forces-Categories (STEEP)

Category	Drivers
Environmental	Climate change Air and water pollution Invasive non-native species Environmental policy
Economic	Economic growth Commondity prices Demand and consumption patterns Income and distribution Market development
Political	Macroeconomic policy Land-use plans, zoning, management Governance and corruption Property rights and land tenure
Social & Demographic	Population growth/decline Migration Cultural values Education Religious values
Technological	Technological innovation Technology choice

E

E

P

S

T

Examples of Climate Change-Related Drivers

Frequency & magnitude of drought, flood

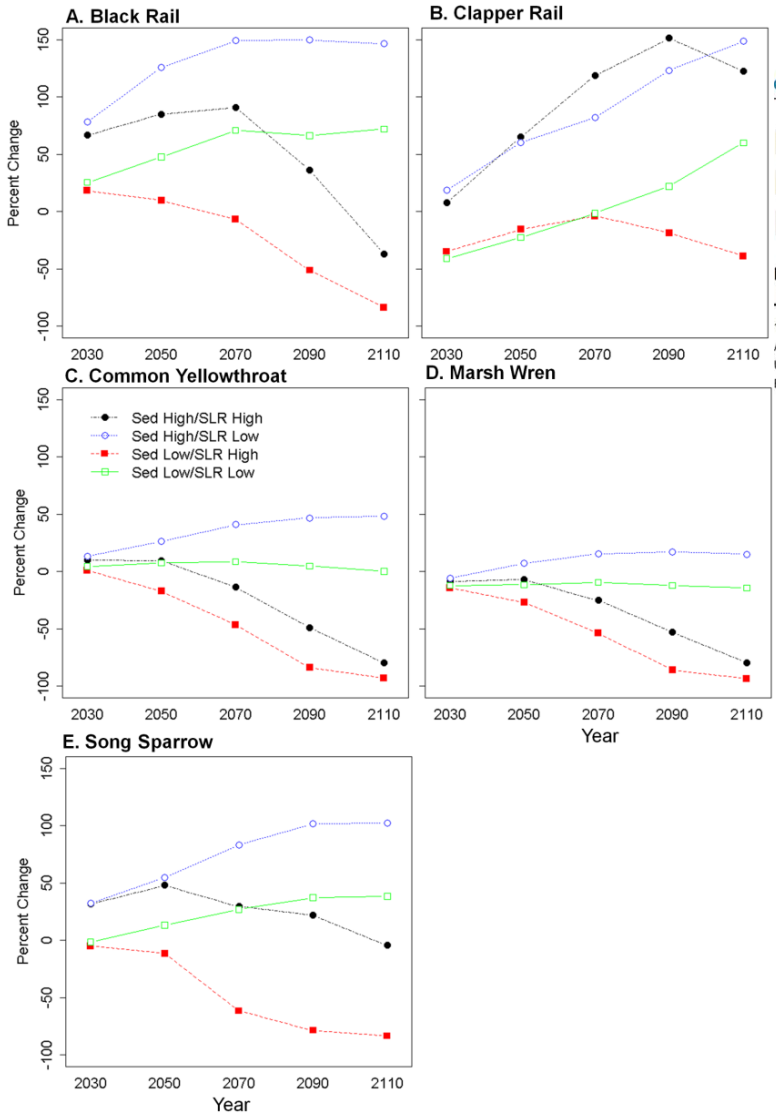
Changes in seasonal patterns of rain & snow

Sea level rise

Storm surge, erosion and washover

Frequency of extreme events

Example: Tidal marsh restoration SF Bay with sea level rise`



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PLoS one

Evaluating Tidal Marsh Sustainability in the Face of Sea-Level Rise: A Hybrid Modeling Approach Applied to San Francisco Bay

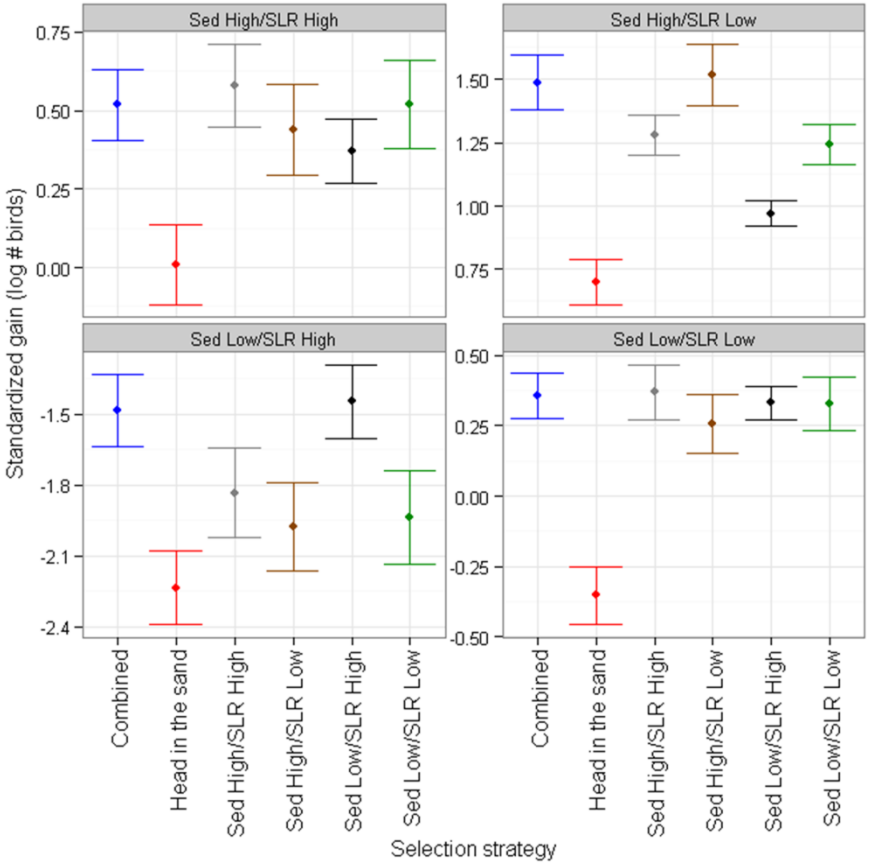
Diana Stralberg[1,2]*, Matthew Brennan[3], John C. Callaway[4], Julian K. Wood[1], Lisa M. Schile[5], Dennis Jongsomjit[1], Maggi Kelly[5], V. Thomas Parker[6], Stephen Crooks[3]

1 Climate Change and Informatics Group, PRBO Conservation Science, Petaluma, California, United States of America, **2** Department of Biological Sciences, University of Alberta, Edmonton, Canada, **3** Estuaries and Wetlands Team, ESA PWA, San Francisco, California, United States of America, **4** Department of Environmental Science, University of San Francisco, San Francisco, California, United States of America, **5** Department of Environmental Science, Policy and Management, University of California at Berkeley, Berkeley, California, United States of America, **6** Department of Biology, San Francisco State University, San Francisco, California, United States of America

SF Bay: Assessing Impacts

of birds added with restoration projects in each scenario

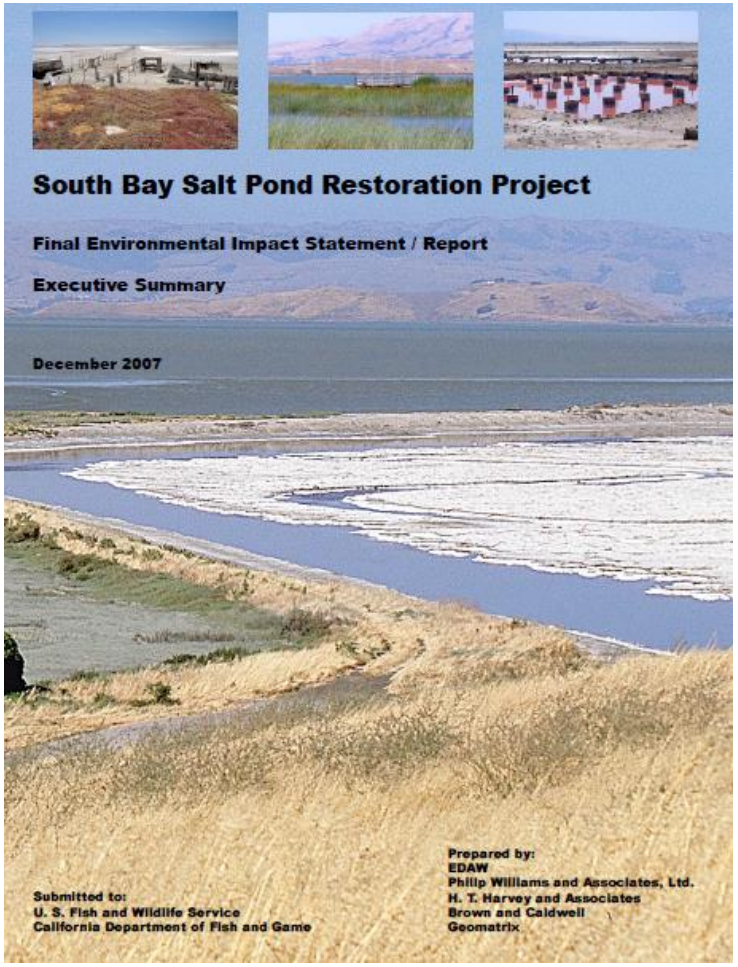
Evaluating different project selection strategies



Veloz et al. 2013. Ecosphere

Adaptive Management Plan for South Bay Salt Pond Restoration Project

- Specified **hypotheses** and **key uncertainties** and research to address them
- Specified **triggers** for action
- Specified necessary **science and institutional structure** for adaptive management to work



Really cool table!

For each goal/target:

- What they'll monitor and where
- When they'll make decisions
- What observations would trigger a re-examination of their plans
- Action options once a trigger is tripped
- Key knowledge gaps and how they're filling them

MANAGEMENT TRIGGER	APPLIED STUDIES
▪ Outboard mudflat decreases greater than the range of natural variability + observational variability/error.	▪ Will sediment movement into restored tidal areas significantly reduce habitat area and/or ecological functioning (such as plankton, benthic, fish or bird diversity or abundance) in the South Bay? ▪ Development of a 2- and 3-D South Bay tidal habitats evolution model.
POTENTIAL MANAGEMENT ACTION	
▪ Convene study session to review and interpret findings to assess if observed changes are due to restoration actions or system-wide changes in the sediment budget (*e.g.*, effects of sea level rise). ▪ Study biological effects of loss of mudflat, subtidal shallows, and/or subtidal channel habitat. ▪ Adjust restoration phasing and design to reduce net loss of tidal mudflats. Potential actions include remove bayfront levees to increase wind fetch and sustain tidal mudflat, phase breaching to match demand and supply, and/or breach only high-elevation ponds to limit sediment demand ▪ Reconsider movement up staircase	

Decision sensitivity analysis

- How sensitive is my decision to this uncertainty?
- What’s the value of the information?

Risk Attitude

- Risk-averse
  - E.g., buying insurance
- Risk-seeking
  - E.g., buying lottery tickets

Expected Value, Minimum Payoff, & Robustness

Action	Outcome				EV	Maxi-Min	P>15
	0	10	20	30			
A	.25	.25	.25	.25	15	0	50%
B	.00	.25	.50	.25	20	10	75%
C	.10	.20	.00	.70	23	0	70%
D	.20	.00	.80	.00	16	0	80%