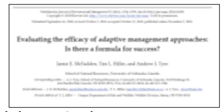
WFA8433-Natural Resource & Conservation Decision Making

Class 5 Introduction to structured decision making in natural resources management; History, rational, and applications of decision making in natural resources

Housekeeping

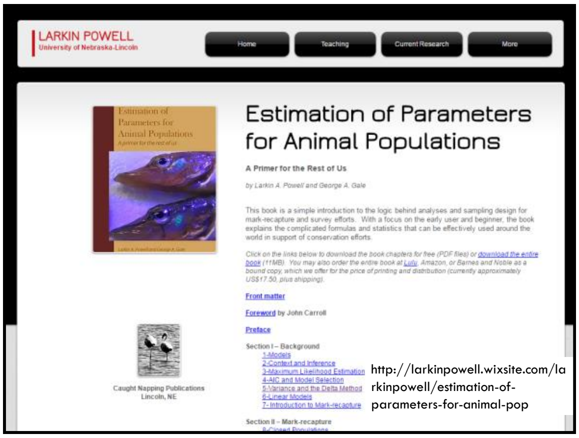
- Suggested readings:
  - Conroy & Peterson Chapter 1



- Assignment(s): Read McFadden et al.
- Group work: If time allows discuss projects
- Netica – Limited version is sufficient

Free Version

To use the free version of Netica, download the regular Application, leave the password dialog box empty and click on 'Limited Mode'. The free demo version is full-featured but limited in model size. Contact us for full details.


LARKIN POWELL
University of Nebraska-Lincoln
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Estimation of Parameters for Animal Populations

A Primer for the Rest of Us

by Larkin A. Powell and George A. Gale

This book is a simple introduction to the logic behind analyses and sampling design for mark-recapture and survey efforts. With a focus on the early user and beginner, the book explains the complicated formulas and statistics that can be effectively used around the world in support of conservation efforts.

Click on the links below to download the book chapters for free (PDF files) or download the entire book (11MB). You may also order the entire book at Lulu, Amazon, or Barnes and Noble as a bound copy, which we offer for the price of printing and distribution (currently approximately US$17.50, plus shipping).

Front matter

Foreword by John Carroll

Preface

Section I – Background
1-Models
2-Context and Inference
3-Maximum Likelihood Estimation
4-AIC and Model Selection
5-Variance and the Delta Method
6-Linear Models
7-Introduction to Mark-recapture

Section II – Mark-recapture

Caught Napping Publications
Lincoln, NE

http://larkinpowell.wixsite.com/larkinpowell/estimation-of-parameters-for-animal-pop

DECISION TREES AND NETS CONTINUED

There is uncertainty surrounding most decisions!

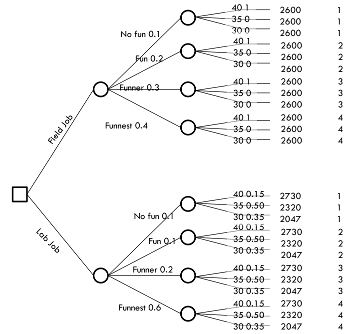
A decision model assimilates:

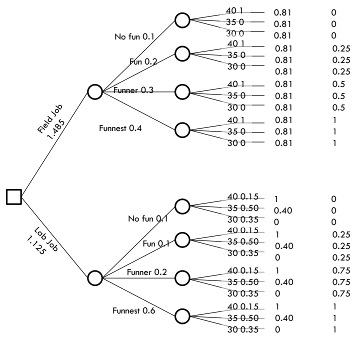
- Decision Alternatives
- Understanding
- Uncertainty
- Utility→Objectives

A more complicated tree, from Class 4…

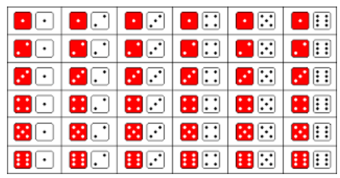
Which Summer internship offer should I take?

- Decision alternatives
  - field experience or lab experience
- Uncertainty
  - How many hours will I get to work
  - How fun will it be?





Where do probabilities come from?



1. **Empirical Data (example follows)**
2. **Simulation**
3. **Experts**

$$\frac{1}{6} \cdot \frac{1}{6} = \frac{1}{36} = 0.023$$

ANOTHER APPLIED EXAMPLE

How should I get home?
Objective: minimize impact on spouse
Utility: min(Time to get home)

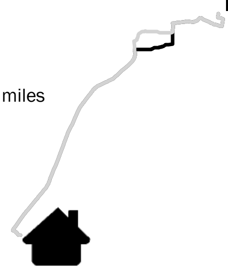
How should I get home from work?

Route A: 7.2 miles

Objective:
Minimize travel time!

Lets give this a shot…
How should I get home from work?

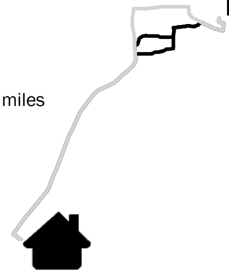
Route B: 7.2 miles



Objective:
Minimize travel time!

Lets give this a shot…
How should I get home from work?

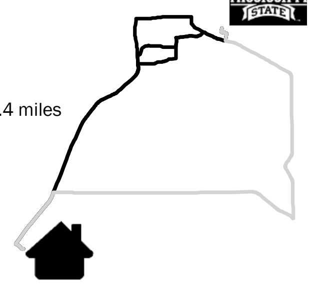
Route C: 7.4 miles



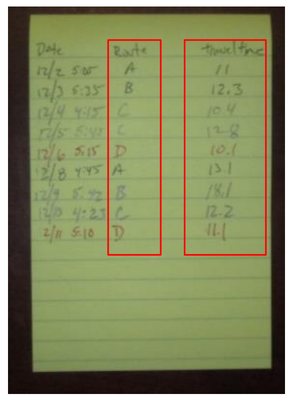
Objective:
Minimize travel time!

Lets give this a shot…
How should I get home from work?

Route D: 11.4 miles



Objective:
Minimize travel time!

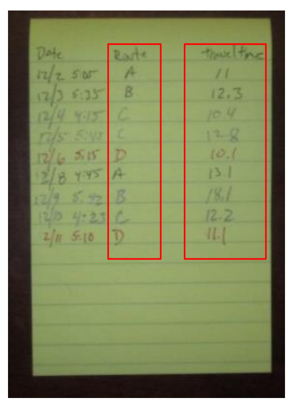


Date	Route	travel time
12/2 5:05	A	11
12/3 5:35	B	12.3
12/4 4:15	C	10.4
12/5 5:45	C	12.8
12/6 5:15	D	10.1
12/8 4:45	A	13.1
12/9 5:42	B	18.1
12/10 4:23	C	12.2
12/11 5:10	D	11.1

How should I get home from work?

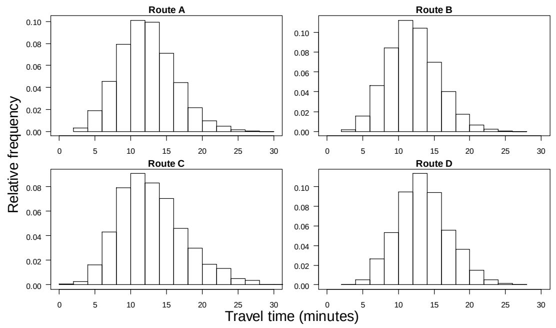
Route	Distance (miles)
A	7.2
B	7.2
C	7.4
D	11.4

Objective:
Minimize travel time!

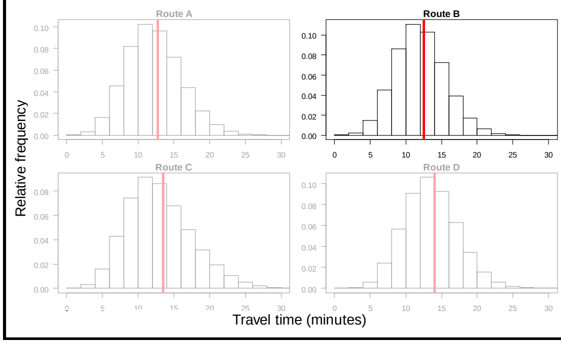


Date	Route	travel time
12/2 5:05	A	11
12/3 5:35	B	12.3
12/4 4:15	C	10.4
12/5 5:45	C	12.8
12/6 5:15	D	10.1
12/8 4:45	A	13.1
12/9 5:42	B	18.1
12/10 4:23	C	12.2
12/11 5:10	D	11.1

How to decide with this uncertainty?



How to decide with this uncertainty?



Decision model

Decision Alternatives

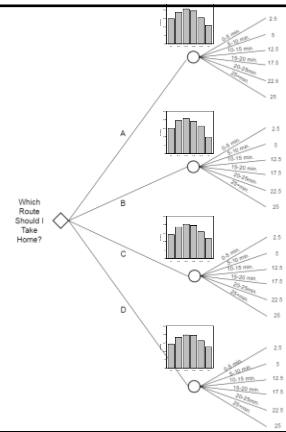
- 4 routes

Uncertainty

- Accounted for uncertainty in travel times

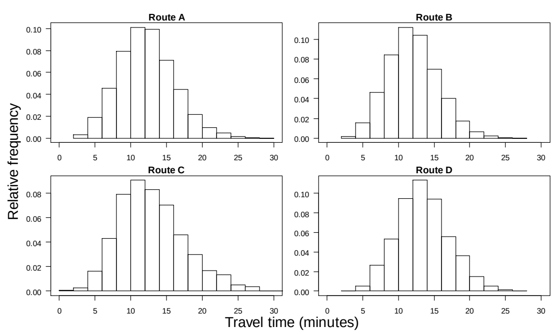
Utility→Objectives

- Minimize travel time

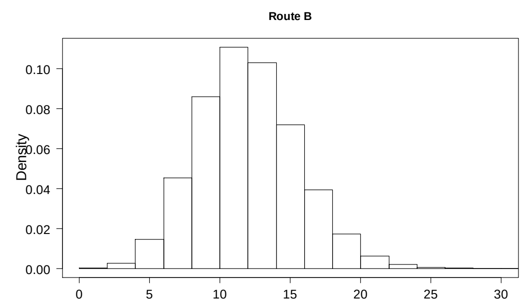


24 paths

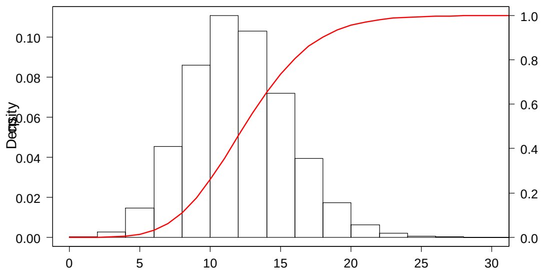
Probabilities?



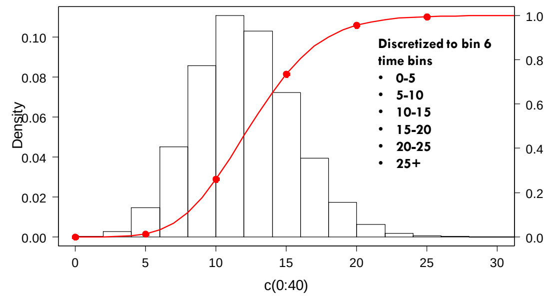
Distribution of Data



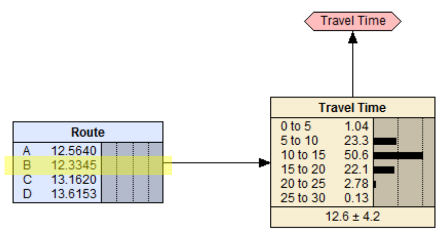
Cumulative Distribution



Cumulative Distribution

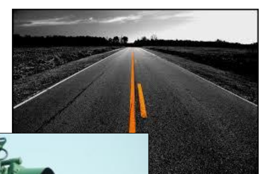


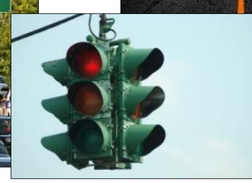
A network decision model



Factors that effect travel time?

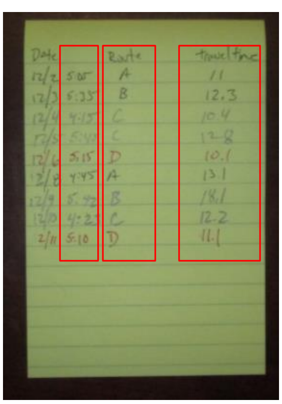
- Distance…. Can't change distance for each route
- Traffic…rush hour… lights

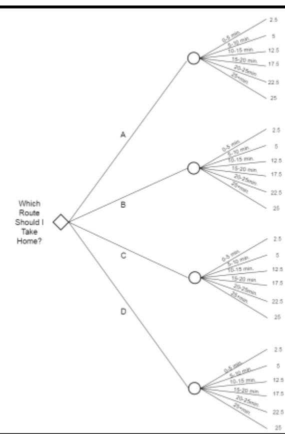




Classify departure times of:

- 4-4:30
- 4:30-5
- 5:5:30
- 5:30-6





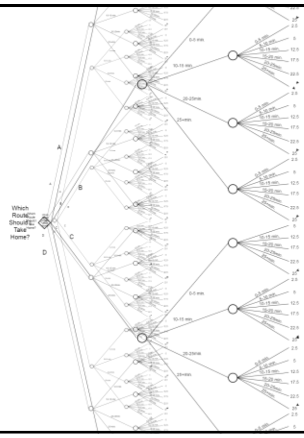
24 paths

But add departure times of:

- 4-4:30
- 4:30-5
- 5:5:30
- 5:30-6

Just 4 more combos right?

80 Paths!



I will be leaving work sometime between 4 and 6 pm

-Route B is optimal

Travel Time

Route	
Take A	11.7606
Take B	11.5058
Take C	12.5084
Take D	13.0241

Travel Time	
0 to 5	1.39
5 to 10	24.6
10 to 15	47.7
15 to 20	22.0
20 to 25	3.94
25 to 30	0.41
12.7 ± 4.5	

Departure time	
4:00-4:30	25.0
4:30-5:00	25.0
5:00-5:30	25.0
5:30-6:00	25.0
2.5 ± 1.1	

We can make better decisions if things are known with certainty

What time will I leave work?

I am 100% sure I will leave between 4 and 4:30

-Route A is optimal

Travel Time

Route	
Take A	9.98139
Take B	11.5000
Take C	10.9906
Take D	13.0372

Travel Time	
0 to 5	1.96
5 to 10	30.1
10 to 15	48.6
15 to 20	17.3
20 to 25	1.96
25 to 30	.092
11.9 ± 4.2	

Departure time	
4:00-4:30	100
4:30-5:00	0
5:00-5:30	0
5:30-6:00	0
1	

I am 100% sure I will leave between 4:30 and 5:00

- Route A is optimal

Travel Time

Route	
Take A	11.0063
Take B	11.5106
Take C	12.0075
Take D	13.0181

Travel Time	
0 to 5	1.30
5 to 10	25.4
10 to 15	50.3
15 to 20	20.4
20 to 25	2.44
25 to 30	0.11
12.4 ± 4.2	

Departure time	
4:00-4:30	0
4:30-5:00	100
5:00-5:30	0
5:30-6:00	0
2	

I am 100% sure I will leave between 5 and 5:30

-Route B is optimal

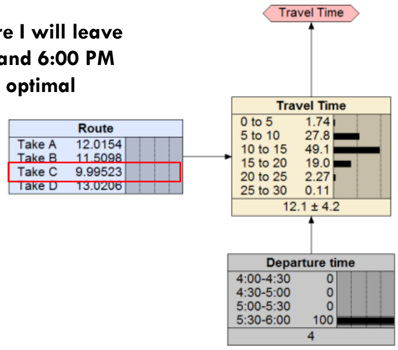
Travel Time

Route	
Take A	14.0393
Take B	11.5027
Take C	17.0404
Take D	13.0206

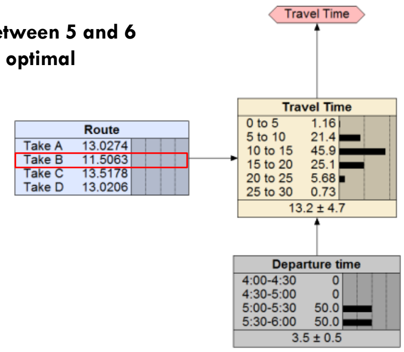
Travel Time	
0 to 5	0.58
5 to 10	15.0
10 to 15	42.7
15 to 20	31.3
20 to 25	9.09
25 to 30	1.35
14.4 ± 4.8	

Departure time	
4:00-4:30	0
4:30-5:00	0
5:00-5:30	100
5:30-6:00	0
3	

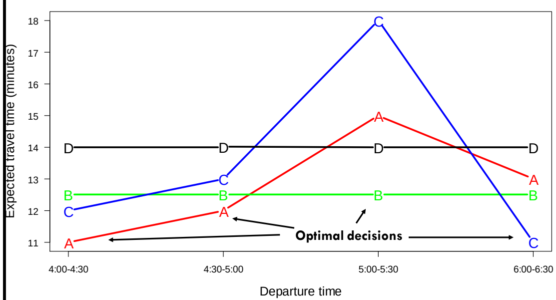
I am 100% sure I will leave between 5:30 and 6:00 PM
- Route C is optimal



I will leave between 5 and 6
-Route B is optimal



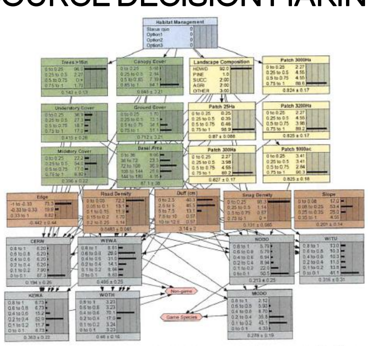
Decision uncertainty: The optimal decision varies with departure time



Challenge for you

- Can you think of an efficient way to get probabilities for ALL 80 paths?

INTRODUCTION TO NATURAL RESOURCE DECISION MAKING



What is NR management?

- Taking an action to obtain some desired resource outcome
- Requires:
  - A range of alternative actions that can be taken
  - An objective we're trying to achieve

NR Management means making a decision

Decision definition: *"an irrevocable commitment of resources"*

- Examples of decisions
  - Stock a reservoir
  - Set harvest regulations
  - Limit public access
- Examples of not decisions
  - Set up a task force to study a problem
  - Establish a conservation priority list

Example Natural Resource Decision

- Objective: increase habitat availability to increase fish population
- Decision: minimum flows
- Model:
  - (Good) If I increase flows, then habitat increases
  - (Better) If I increase flows by X cms then habitat availability will increase by Y %
  - (Even better) If I increase flows by X cms, habitat availability will increase by Y % and the population will increase by Z%

Fundamental assumption of this course: **<u>All management is based on models!</u>**

Problems with Black Box Approaches to Management

- Generally not explicit or transparent
- Many unidentified and unstated assumptions
- <u>Not</u> transferable or repeatable
- <u>No</u> formal learning component
- <u>MANY</u> uncertainties

Sources of uncertainty on NR decision making

- Environmental uncertainty due to environmental and demographic variation
- Statistical uncertainty due to the use of sample data to estimate parameters
- Ecological (system) uncertainty due to incomplete understanding of system dynamics

Elements of SDM & ARM

- Set of decision alternatives
- Prediction of outcome to each action
- Decision objective
- Additional elements required for ARM:
  - A sequence of decisions through time
  - Set of predictive models
  - Discrete set or continuous set
  - Measure of relative confidence applied to each model
  - Monitoring program to assess model predictions

Adaptive resource management

- Is not unfocused trial and error
  - The decision components (objectives, models, weights) provide clear decision direction
- Is not experimentation
  - Learning is valued, but only to the extent that management is measurably improved
- Does not necessarily imply different decisions triggered by changing resource or environmental conditions
  - Adaptation is all about change in the model credibility weights
- Is not a consensus tool for resolving different stakeholder values
  - Competing objectives must be resolved externally of AM

Adaptive resource management

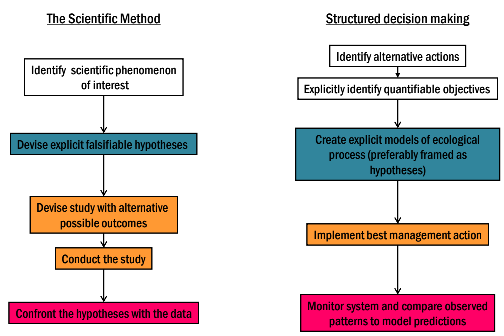
Iterated decision making in the face of structural uncertainty, with a focus on its reduction

B. K. Williams

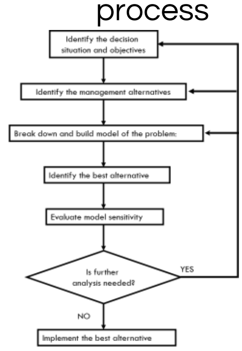
History

Emergence of SDM/ARM
- 1890: Chamberlin
  "The method of multiple working hypotheses"
- 1950s-60s: Bellman and others
  Theory of optimal control of uncertain dynamic systems
- 1970s-80s: Walters, Holling, Hilborn
  Theory & model development for regulation of fisheries
- 1980s-90s: Williams, Johnson, Nichols, & others
  First widely successful wildlife management application
- Currently:
  Applications development in endangered species reintroduction, habitat & landscape management, etc.

The Scientific Method and Natural Resource Decision-Making



Structured decision-making process



All of this occurs AFTER establishing governance in multi-stakeholder SDM

Why Use SDM/ARM

1. Transparency & Stakeholder involvement
2. Clarify connection of decisions to objectives
3. Retain institutional knowledge
4. Integration of Monitoring to Decision

Why involve stakeholders?

- Natural resource decisions
  - trust resources
  - multiple uses and competition
- Increase transparency
- Identify values and concerns among users
- Minimize or resolve conflicts
- Build public support

Public Trust Resources

The North American Model
- Belong to everyone
- Can't sell wild deer
- Allocate by law
- Kill for legitimate reasons (food, fur, protection)
- "Science based policy"
- Everyone should have access

Reality check: Decision makers & Stakeholders

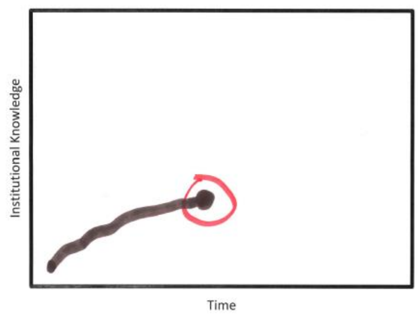
- All decision makers are stakeholders
- Not all stakeholders are decision makers
- Decision makers
  - legal authority/mandate
  - management resources
- Stakeholder analysis

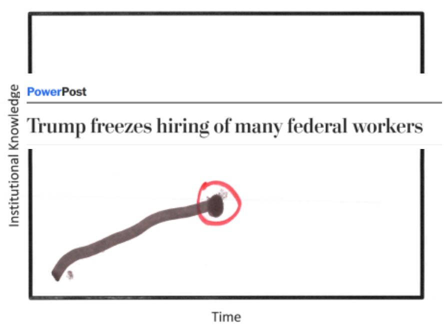
Question for thought: *in collaborative efforts, do decision makers give-up decision making authority to stakeholders? To scientists?*

Clarify connection of decisions to objectives

- Many times management actions are implemented that do not meet objectives
- *"We will monitor the population"*

Loss of Institutional Knowledge



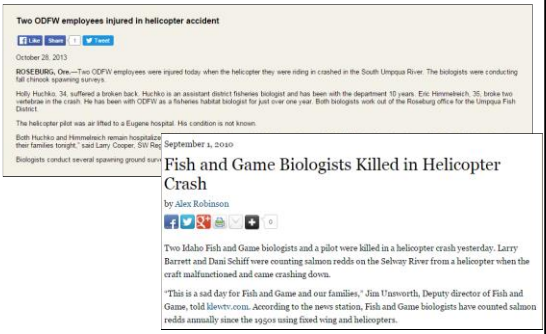


Integration of Monitoring to Decision

- Surveillance & trend monitoring
- React to problems after they happen
- Poor use of information
  - State dependent decisions?
- Put off decision until more information is available (paralysis by analysis)

"We know now how to make good decisions, while always striving to do better with future decisions"

Monitoring is dangerous work



Two ODFW employees injured in helicopter accident

Like Share 1 Tweet

October 28, 2013

ROSEBURG, Ore.—Two ODFW employees were injured today when the helicopter they were riding in crashed in the South Umpqua River. The biologists were conducting fall chinook spawning surveys.

Holly Huchko, 34, suffered a broken back. Huchko is an assistant district fisheries biologist and has been with the department 10 years. Eric Himmelreich, 35, broke two vertebrae in the crash. He has been with ODFW as a fisheries habitat biologist for just over one year. Both biologists work out of the Roseburg office for the Umpqua Fish District.

The helicopter pilot was air lifted to a Eugene hospital. His condition is not known.

Both Huchko and Himmelreich remain hospitalize
their families tonight," said Larry Cooper, SW Reg

Biologists conduct several spawning ground surv

September 1, 2010

Fish and Game Biologists Killed in Helicopter Crash

by Alex Robinson

0

Two Idaho Fish and Game biologists and a pilot were killed in a helicopter crash yesterday. Larry Barrett and Dani Schiff were counting salmon redds on the Selway River from a helicopter when the craft malfunctioned and came crashing down.

"This is a sad day for Fish and Game and our families," Jim Unsworth, Deputy director of Fish and Game, told klewtv.com. According to the news station, Fish and Game biologists have counted salmon redds annually since the 1950s using fixed wing and helicopters.

Remember

A good result may not always result from a specific decision, but if you follow a good process

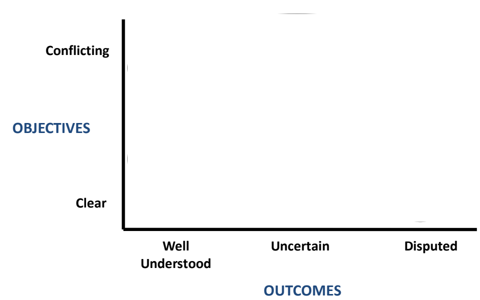
1. Do better in the long run
2. Be able to defend process when results are poor

Bringing SDM/AM into DOI agencies

Formally adopted by the USDOI for managing federal resources

- DOI Guidebook on adaptive management
- Training: Courses on modeling, structured decision making, adaptive management at FWS National Conservation Training Center
- FWS Refuge System
  - Refuge Cooperative Research Program
  - Adaptive Management Consultancy
- Informal efforts
  - Adaptive Management Conference Series
  - ARM for TES workshops

When is SDM Appropriate



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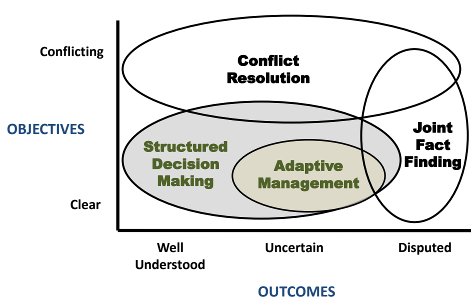
What About Adaptive Management?



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Adaptive resource management?

"__Learning by doing__, and adapting based on what's learned"

"Management in the face of uncertainty, with a focus on the __reduction of that uncertainty__"

"Management that recognizes uncertainty in its consequences and seeks __to improve understanding__, so as to __improve decision making.__"

A special case of SDM

Learning by doing...
...reduction of uncertainty...
...to improve understanding...

Need a **<u>recurrent</u>** application of management actions over time (or space) to:
- Recurrent decision
- Incorporate structural uncertainty by models
- Reduce <u>structural</u> <u>uncertainty by monitoring</u>

Uncertainty has to be high!

Without uncertainty we cannot learn

HOW DO WE LEARN BY DOING?

We could flip the coin many times and calculate the probability of heads.

We can use each flip to learn... Learning by doing!

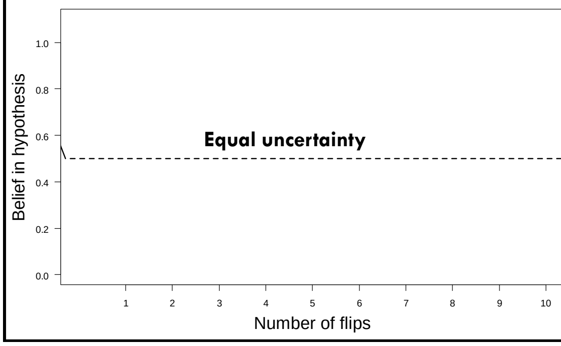
Hypotheses
1. Fair: probability of head = 50%
2. Unfair: probability of heads = 30%

<u>Each</u> flip provides additional information to learn from.

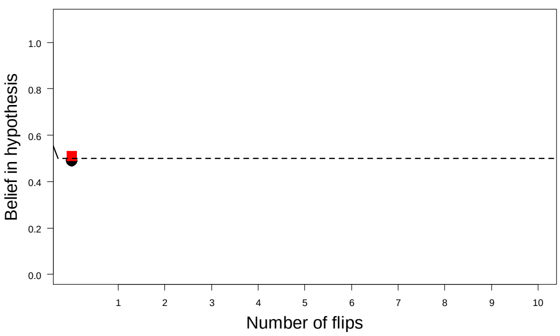
We begin completely uncertain about each hypothesis.

Hypothesis	Prior Probability
Fair coin	***0.5***
Unfair coin	***0.5***

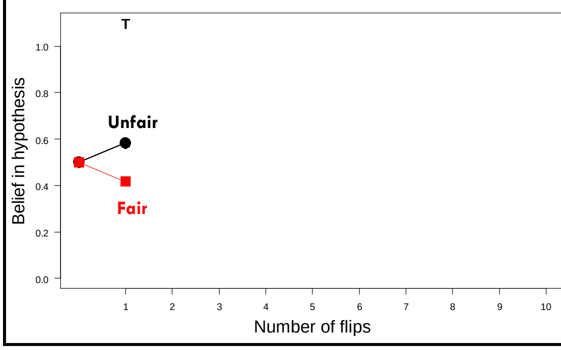
Equal uncertainty



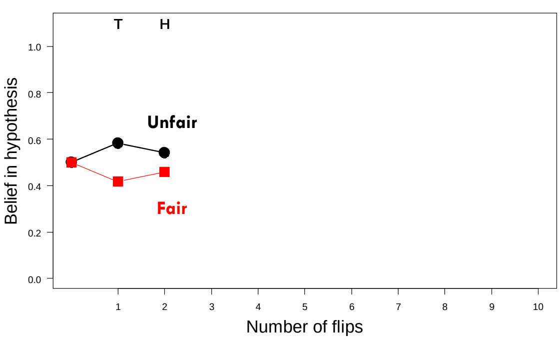
Start with prior beliefs…



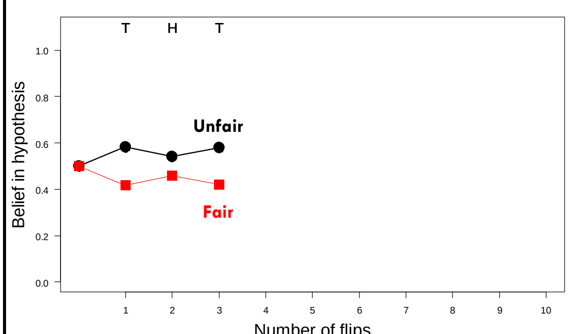
Flip, get a tail and update with Bayes rule



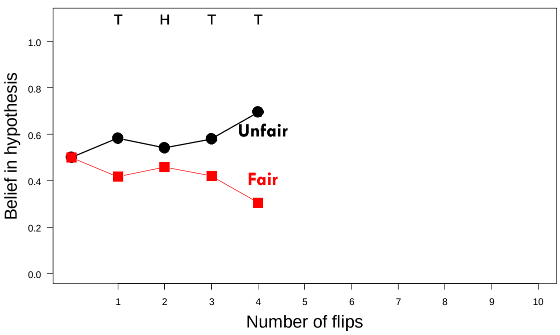
Fair versus unfair, flip #2



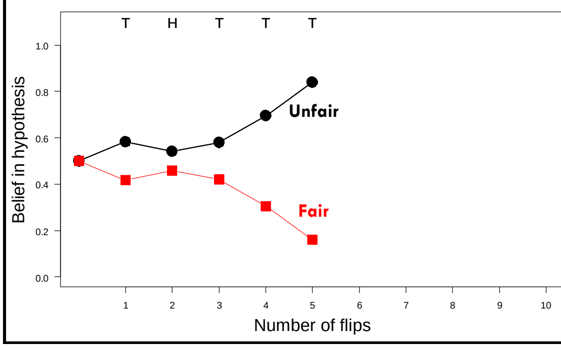
Fair versus unfair, flip #3



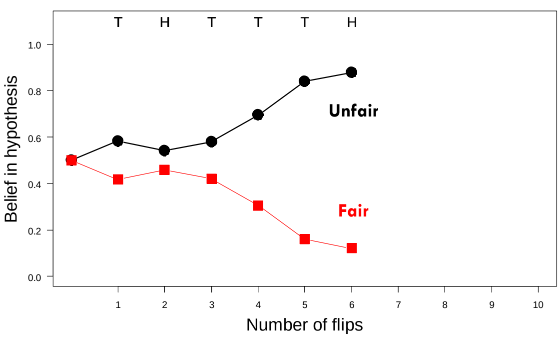
Fair versus unfair, flip #4



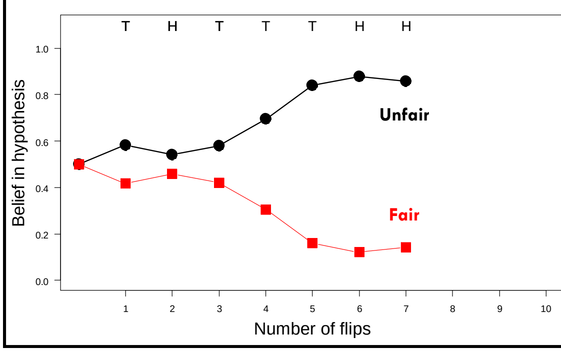
Fair versus unfair, flip #5



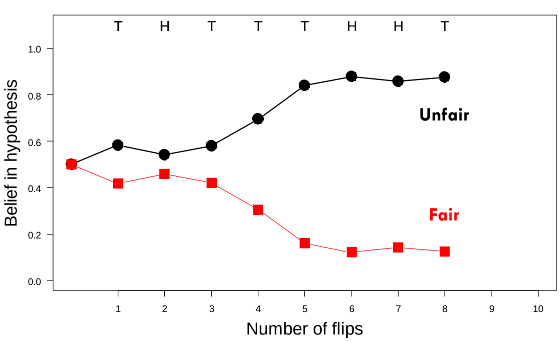
Fair versus unfair, flip #6



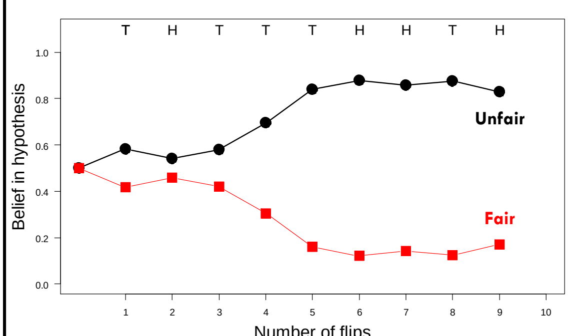
Fair versus unfair, flip #7



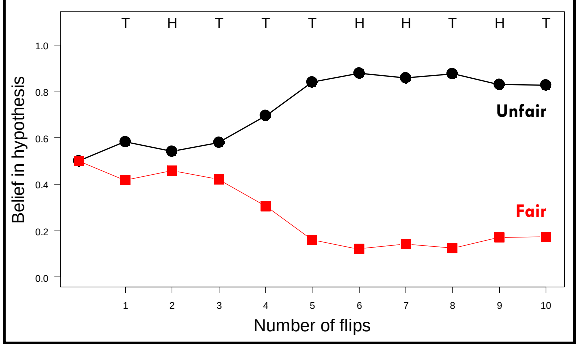
Fair versus unfair, flip #8



Fair versus unfair, flip #9



Strong support for an unfair coin!



Just pretty flow charts?