


# **Decision Analysis of Field Sampling Strategies to Support Ecological Risk Assessment**

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# Informal Decision-Making



- Benefits of jaywalking: Time-savings
- Risks: (1) Probability/consequences of injury; (2) Probability/consequences of ticket (\$\$ cost, embarrassment)



# Key Elements of All Decisions

1. *Objective(s)* (save time; minimize chance of injury or ticket), often conflicting.
2. *Alternatives* (jaywalk or don't)
3. *Consequences* or outcomes (which can be measured by criteria/attributes such as time to cross the road, probability of injury, or probability of getting a ticket).



# Complex Decisions

- Multiple, conflicting objectives
- No single alternative performs best for all of the measurement criteria.

Jaywalking saves time but comes with risk of injury or ticket. Using a cross-walk takes longer but the risk of injury or a ticket is near-zero.



Source: <http://structureddecisionmaking.org>

# Example: Remediation Decision

Decision Context:	Waterfront property; contaminated soil and groundwater; potential for off-site migration
Objectives:	1. Minimize costs. 2. Reduce potential for impacts on surface waters 3. Minimize liabilities.
Evaluation Criteria	1. Cost to remediate now. 2. Probability and cost of future remediation if off-site migration causes future impacts. 3. Probability and consequences for reputation if impacts occur.
Alternatives	1. Monitored natural attenuation; 2. Remove source material now and monitor



## Example: Remediation Decision

	Immediate remediation costs	Probability and cost of future remediation if offsite migration occurs
Monitored natural attenuation	\$0.1M	\$2M, 60% probability
Remove source material	\$0.7M	\$0.5M, 10% probability

Comparison of expected costs:

$$\$0.7M + 0.1(\$0.5M) < \$0.1M + 0.6(\$2M)$$



# Application to Design of Field Sampling Programs for ERA

## Key Challenges in Sampling Design:

- Which types of data (lines of evidence) to collect?
- How much data to collect and when?

## Consequences:

- More data means higher costs up front
- Fewer data means higher probability of the need for multiple field visits, which may ultimately cost more (particularly for remote sites)
- Fewer field visits shortens the time frame



# Case Study

## Context

- Terrestrial site; was cleaned up but there is residual offsite soil contamination (one metal exceeds relevant standard); no HH risks
- Owner wishes to sell, and needs an ERA to obtain a Certificate of Compliance under BC provincial (CSR ) requirements
- Receptors of Concern: small mammals and songbirds

## Objectives

- Complete ERA as quickly as possible
- Minimize cost

# Case Study

Decision Alternatives	Pros	Cons
Estimate COPC concentrations in tissues using BAFs	<ul style="list-style-type: none"><li>• Quick</li><li>• Cheap</li></ul>	<ul style="list-style-type: none"><li>• Likely insufficient, as BAFs for this metal are known to be overly conservative</li></ul>
Measure COPC concentrations in tissues	<ul style="list-style-type: none"><li>• Risk estimates more realistic</li></ul>	<ul style="list-style-type: none"><li>• Longer timeline</li><li>• More costly</li></ul>



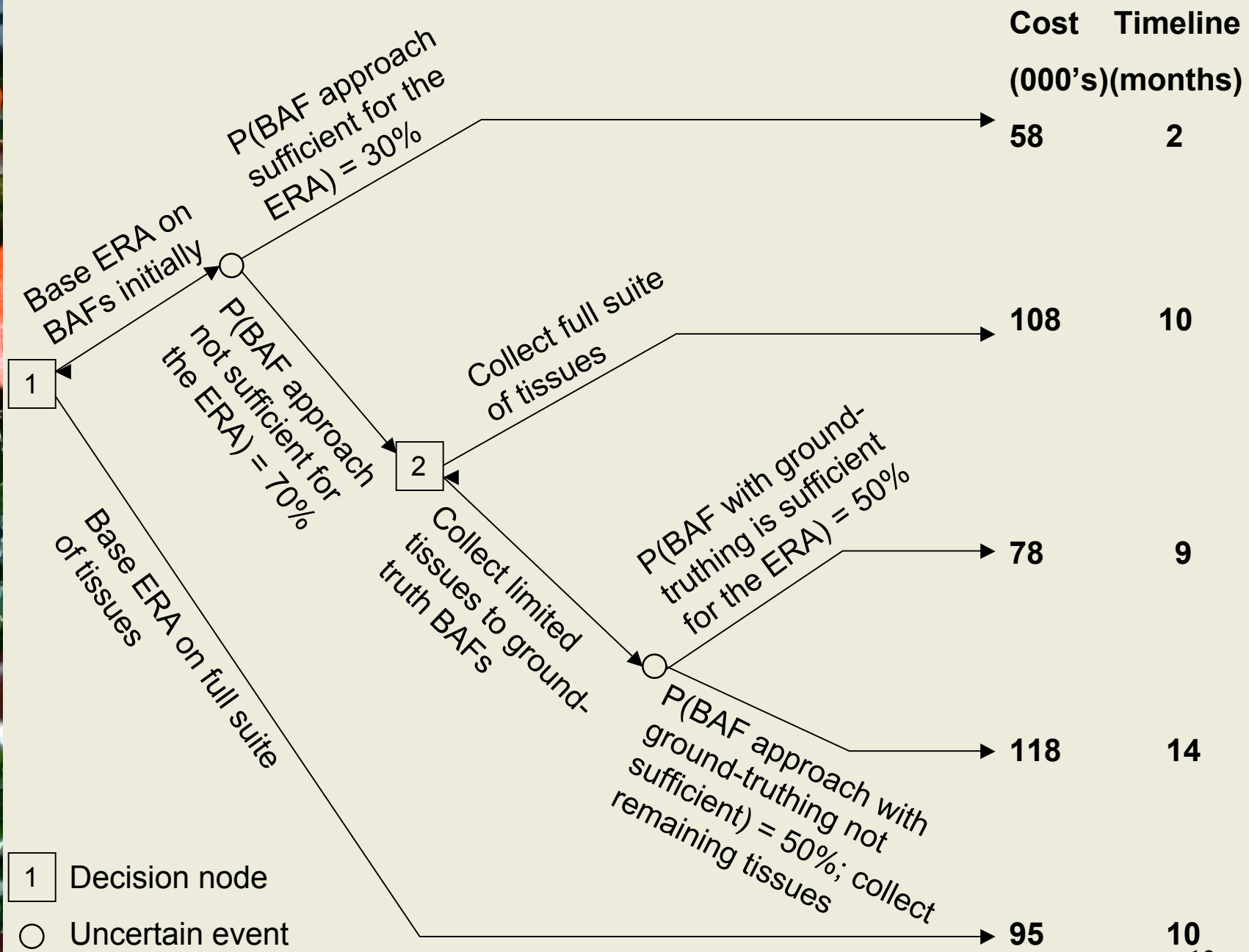
# Case Study

## Evaluation Criterion #1 – Time frame

- Starting point was winter, thus no chance to collect seasonal tissues until spring / summer.
- BAF approach could be completed in 2 months

## Evaluation Criterion #2 – Cost

- Cost of gathering lit-derived BAFs: 8K
- Cost of tissue collection and lab analysis: 15K for limited program (ground-truthing BAFs); 45K for a full program; 55K if the two occur in sequence
- Cost of food web model: 50K under either scenario, or 55K if end up doing both BAF approach and tissue approach

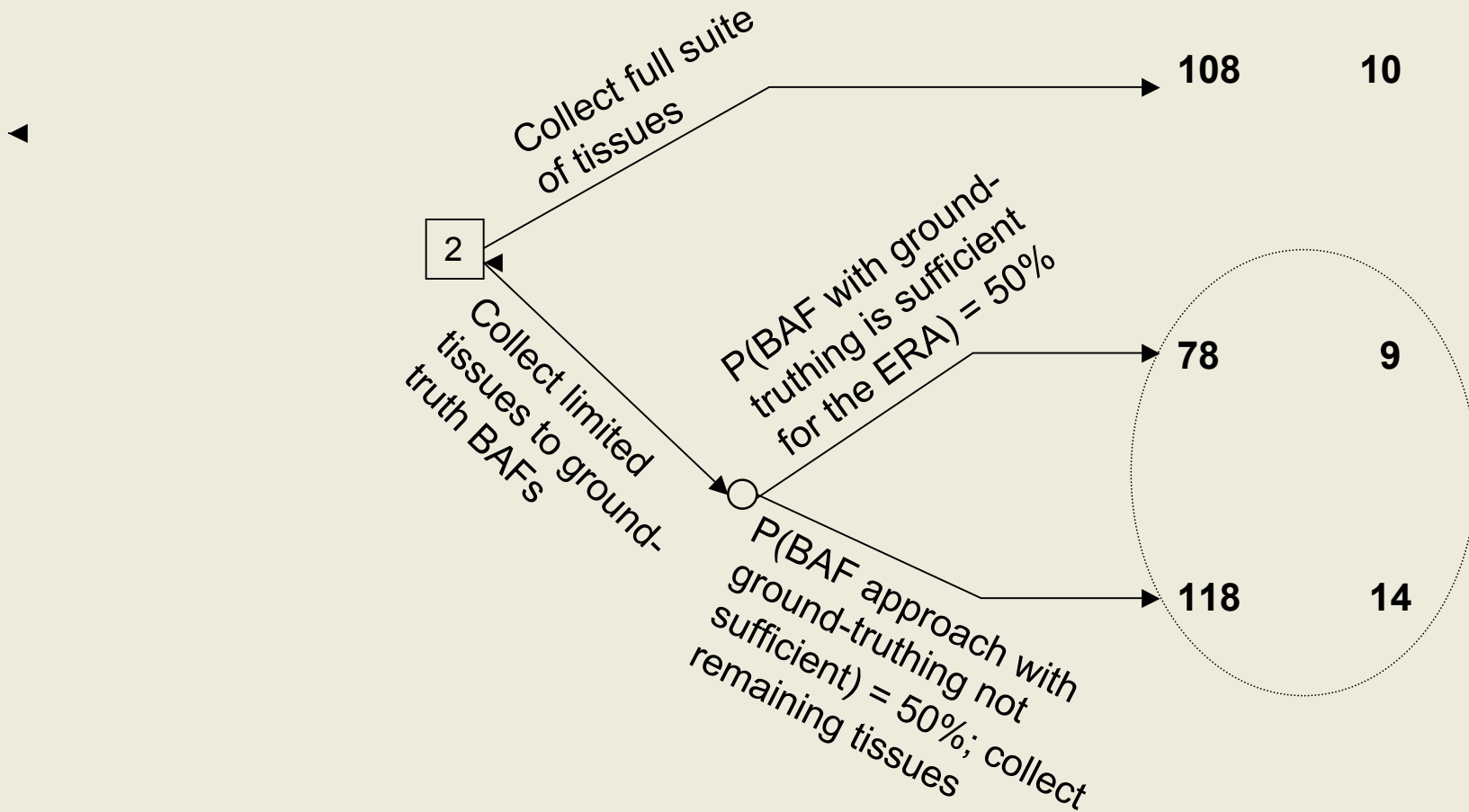


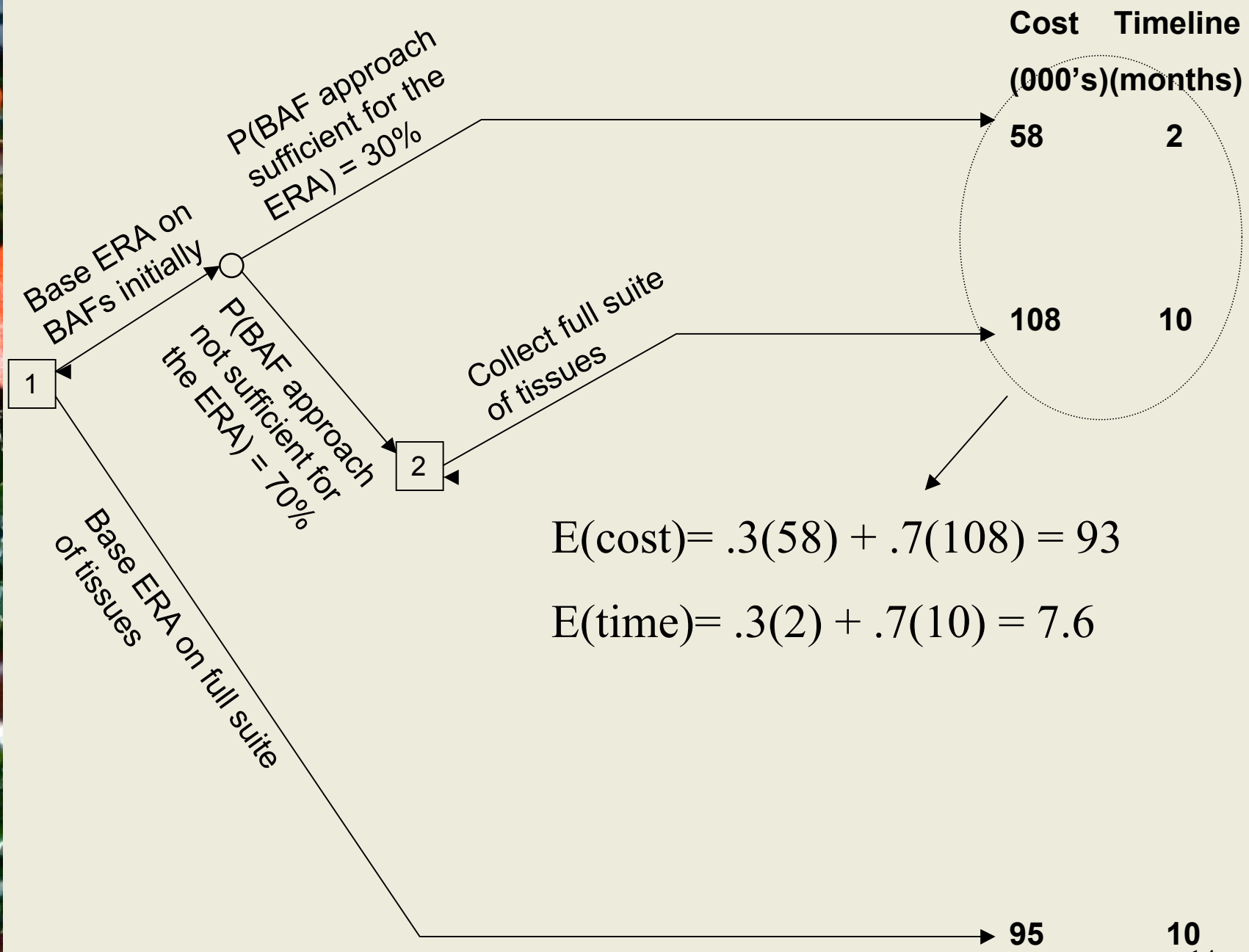


**Cost** **Timeline**  
**(000's)****(months)**

$$E(\text{cost}) = .5(78) + .5(118) = 93\text{K}$$

$$E(\text{time}) = .5(9) + .5(14) = 11.5$$







# Case Study Lessons

- Formalizing the approach led to a better decision - the conclusion to try the BAF approach was not our original gut reaction, because the probability of not needing tissues is low.
- A formal discussion about the client's objectives revealed differences in our team's understanding that had to be clarified
- A formal brainstorm about alternatives revealed choices we had overlooked
- The whole process took only 2 hours, and was considered by all to be worthwhile

## Other Case Study Applications

Sediment investigations:

- Collect sediment for chemistry only, or also collect enough sediment for bioassays and analysis of benthic community abundance and diversity





# Other Approaches

- We used expected values which assume linear trade-off preferences; could have used other approaches such as minimizing “worst-case”
- Decision trees are one tool; there are others (e.g., influence diagrams)
- Decision trees are limited for very complex decisions
- Quantitative simulation can be used, particularly in cases where uncertain events are not dichotomous



Source: <http://structureddecisionmaking.org>



# Conclusions

- We generally rely on our expert judgment and past experience to design field sampling programs for ERA
- Decision analysis approaches can tap into that judgment and experience in a more formalized manner
- For a small amount of effort, such approaches can improve field sampling strategies for ERA

# Thank You

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