


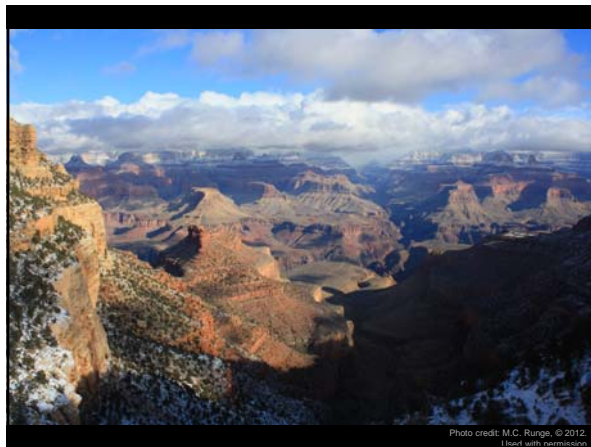
**Using Methods of Decision Analysis to
Aid Federal Agencies:
Descriptive, Prescriptive, and Prospective Tools**

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**Chesapeake Bay Program
Science & Technical Advisory Committee
Quarterly Meeting, Annapolis, MD
7 June 2016**

Outline


- A motivating example
 - Multi-criteria decision analysis to develop an operations plan for Glen Canyon Dam
- Prescriptive (normative, classical) decision analysis
- Prospective decision analysis

Glen Canyon Dam




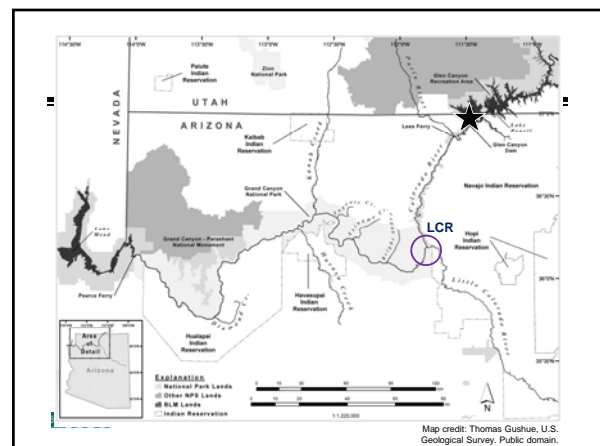
Glen Canyon Dam and Bridge by Adbar. Licensed under CC BY-SA 3.0.

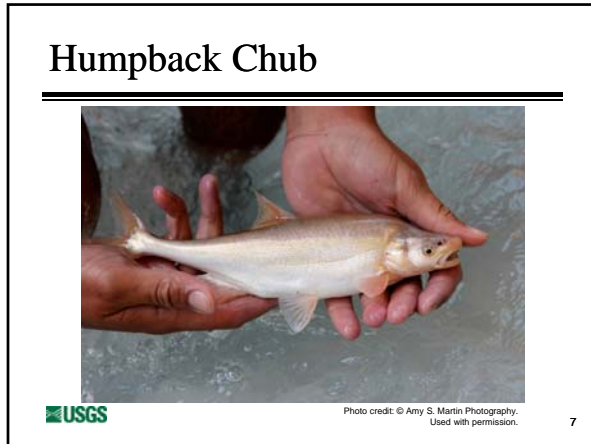


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Dam Operations


- Long-term Experimental & Management Plan (LTEMP)
 - A 20-year plan for operations of Glen Canyon Dam, and related activities
 - Will replace the 1996 Environmental Impact Statement and Record of Decision
 - Draft EIS expected in December 2015
- Developed jointly by Bureau of Reclamation and National Park Service
 - With input from a large number of Cooperating Agencies, Tribes, and other stakeholders



MCDA Process


- MCDA steps to frame and analyze a decision
 - Elicit objectives from decision-makers and stakeholders
 - Develop a set of creative alternatives
 - Evaluate the alternatives (on ecological, economic, social, and spiritual scales)
 - Elicit values-based tradeoffs among the objectives
 - Evaluate uncertainty, using expected value of information
- Central to this approach is recognition that the decision has to discern and integrate social values and scientific understanding



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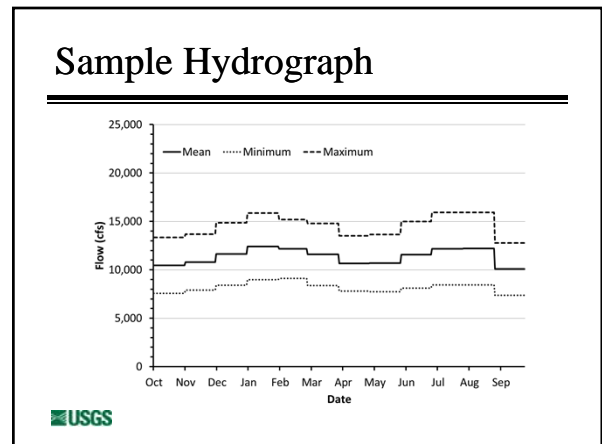
Objectives

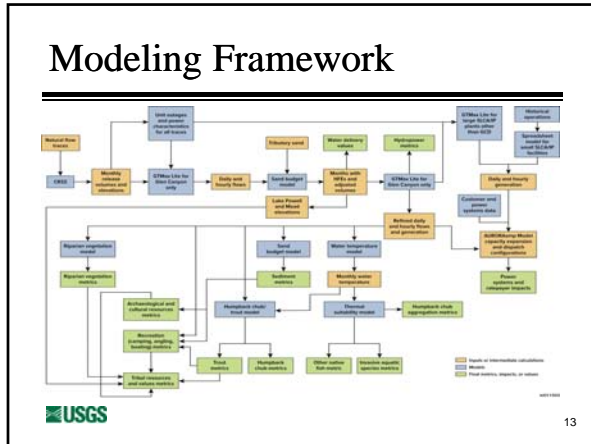
<ul style="list-style-type: none"> ▪ Humpback chub ▪ Native fish ▪ Trout fishery ▪ Archaeological properties ▪ Hydropower generation and capacity 	<ul style="list-style-type: none"> ▪ Recreation ▪ Native vegetation ▪ Sediment deposition ▪ Water delivery ▪ Tribal goals <ul style="list-style-type: none"> • Health of the ecosystem • Respect for life • Sacred integrity
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Alternatives

- Seven alternatives developed for analysis
 - Status quo ("No Action")
 - Two from stakeholder agencies
 - One from the joint-lead agencies
 - Two from concepts discussed in the past
 - One (a "hybrid") developed after analysis of the first six
- Each alternative is a complex portfolio
 - Monthly, daily, hourly flow volumes
 - Various special flow operations
 - Non-flow actions (trout removal, vegetation management)
 - Experimental procedures for untested operations

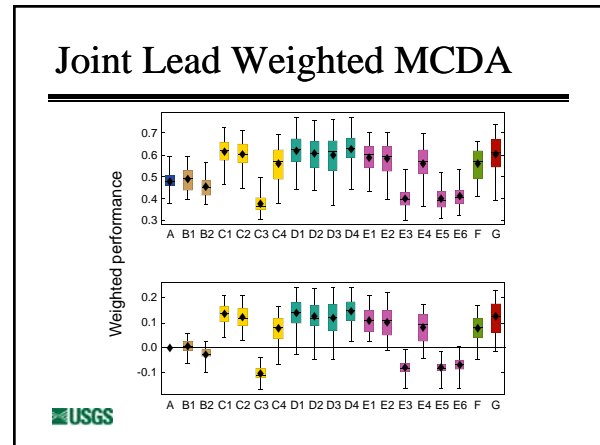
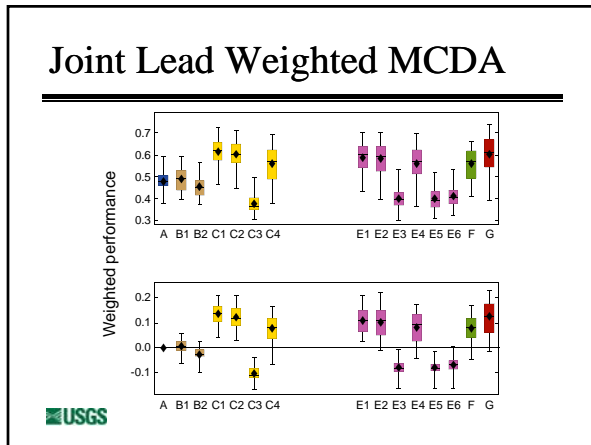


Consequence Table

Best performing alternative for this metric
 Alternative performs better than No Action
 Alternative performs worse than No Action
 Worst performing alternative for this metric

Alternative	Performance Metric																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	HBC	Temp	CPE	Trout	Qual	WTSI	GC	TOR	Power	Cap.	CAI	FI	GC	VEg	SU	Wet	MR	TMF
A	4991	0.097	2.11	36,099	769	0.199	22.7	0.823	128.5	28.5	0.139	0.786	29	3.66	0.211	0.72	0.07	0.0
B1	5392	0.097	1.67	29,586	807	0.474	25.1	0.823	149.4	30.4	0.446	0.425	71	3.81	0.234	0.80	0.44	3.0
B2	5541	0.097	1.46	24,172	920	0.144	23.1	0.823	109.4	32.4	0.122	0.786	72	3.12	0.222	0.17	0.30	3.1
C1	5016	0.082	2.23	43,083	748	0.377	21.8	0.824	147.3	20.8	0.376	0.935	315	3.18	0.536	0.25	0.00	6.5
C2	4527	0.079	3.18	66,890	640	0.365	21.8	0.823	147.2	19.5	0.371	0.929	307	3.18	0.534	0.25	0.00	0.0
C3	5335	0.079	1.90	33,559	830	0.043	18.5	0.821	148.9	20.8	0.041	0.924	0	3.11	0.065	0.25	0.74	0.0
C4	4574	0.079	2.72	55,076	707	0.334	21.0	0.823	147.6	20.8	0.336	0.928	63	2.98	0.483	0.25	2.80	0.0
D1	5247	0.094	2.02	40,784	811	0.379	25.5	0.835	146.6	23.8	0.359	0.741	348	3.07	0.531	0.75	1.67	3.9
D2	5181	0.095	2.15	43,981	796	0.378	25.6	0.835	146.1	19.6	0.360	0.784	351	3.09	0.535	0.76	2.02	6.9
D3	4876	0.095	2.63	55,811	711	0.378	25.5	0.836	146.8	23.8	0.359	0.724	348	3.70	0.533	0.78	2.95	0.0
D4	5241	0.097	2.03	40,536	810	0.380	25.5	0.836	146.7	25.1	0.358	0.741	348	3.59	0.529	0.84	1.99	3.8
E1	5209	0.090	1.63	37,014	826	0.311	21.3	0.839	148.0	22.8	0.361	0.566	177	3.54	0.456	0.62	0.09	2.6
E2	5015	0.086	2.33	47,450	761	0.297	21.3	0.837	147.9	21.8	0.292	0.534	174	3.84	0.443	0.85	0.00	0.0
E3	5477	0.087	1.68	28,499	891	0.030	18.4	0.836	149.3	0.028	0.517	0	3.93	0.046	1.10	0.47	0.0	
E4	5103	0.087	2.19	42,808	781	0.241	20.9	0.838	148.1	22.8	0.272	0.529	79	3.91	0.445	0.91	1.73	0.0
E5	4870	0.083	1.68	28,861	890	0.026	18.5	0.835	147.2	21.8	0.026	0.517	0	3.87	0.046	1.05	0.40	0.0
E6	4508	0.087	1.42	22,415	956	0.032	18.8	0.837	149.3	22.8	0.030	0.518	0	3.92	0.049	1.10	0.00	2.4
F	4450	0.030	1.37	21,869	592	0.299	30.8	0.750	141.0	11.1	0.406	0.991	309	3.14	0.558	0.44	0.00	0.0
G	4741	0.102	2.81	58,533	702	0.468	24.7	0.840	142.9	18.0	0.451	0.981	512	3.40	0.576	0.42	0.05	11.0

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MCDA by Agency

Alternative	Stakeholder Agency												
	Joint Lead	Federal	State	State	Utility	Utility	Utility	Tribes	Tribes	Tribes	NGO	NGO	NGO
A	0.479	0.508	0.453	0.448	0.472	0.448	0.459	0.515	0.530	0.477	0.508	0.450	0.429
B1	0.488	0.504	0.511	0.450	0.493	0.485	0.474	0.512	0.538	0.495	0.511	0.474	0.443
B2	0.454	0.434	0.447	0.402	0.491	0.495	0.484	0.457	0.477	0.446	0.504	0.416	0.384
C1	0.615	0.539	0.484	0.508	0.458	0.410	0.410	0.574	0.599	0.521	0.544	0.604	0.637
C2	0.602	0.519	0.465	0.518	0.426	0.376	0.391	0.570	0.591	0.511	0.540	0.589	0.631
C3	0.576	0.443	0.378	0.468	0.418	0.400	0.412	0.441	0.446	0.444	0.446	0.446	0.450
C4	0.559	0.507	0.452	0.497	0.441	0.392	0.405	0.532	0.544	0.488	0.528	0.555	0.573
D1	0.619	0.573	0.542	0.540	0.489	0.450	0.436	0.596	0.630	0.559	0.553	0.634	0.648
D2	0.607	0.574	0.526	0.535	0.470	0.424	0.414	0.581	0.615	0.547	0.534	0.630	0.642
D3	0.599	0.557	0.526	0.540	0.492	0.425	0.428	0.584	0.614	0.550	0.544	0.621	0.637
D4	0.625	0.590	0.560	0.553	0.500	0.460	0.445	0.610	0.646	0.574	0.559	0.647	0.662
E1	0.589	0.535	0.522	0.506	0.475	0.447	0.430	0.572	0.607	0.535	0.550	0.587	0.592
E2	0.583	0.539	0.533	0.515	0.459	0.428	0.418	0.579	0.616	0.542	0.547	0.588	0.594
E3	0.480	0.488	0.482	0.411	0.430	0.445	0.434	0.463	0.483	0.445	0.461	0.373	0.319
E4	0.560	0.543	0.523	0.509	0.468	0.436	0.427	0.563	0.597	0.536	0.534	0.575	0.569
E5	0.400	0.481	0.474	0.406	0.438	0.454	0.422	0.459	0.482	0.457	0.459	0.369	0.318
E6	0.412	0.498	0.492	0.415	0.460	0.463	0.460	0.469	0.491	0.451	0.467	0.382	0.326
F	0.559	0.465	0.396	0.484	0.311	0.269	0.293	0.509	0.536	0.411	0.475	0.535	0.622
G	0.609	0.599	0.478	0.532	0.456	0.385	0.297	0.563	0.588	0.424	0.514	0.611	0.609

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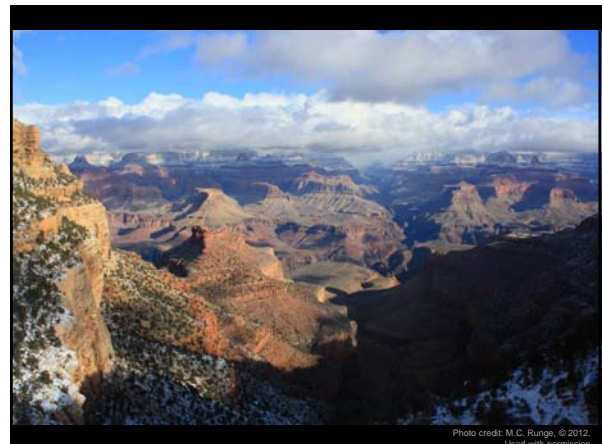
Sensitivity Analysis

- Used Expected Value of Information to evaluate the effect of uncertainty on the ranking of alternatives
 - Effect of hydrology, sediment input
 - Effect of climate change
 - Effects of various hypotheses regarding the response of trout and chub to actions

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Outcomes


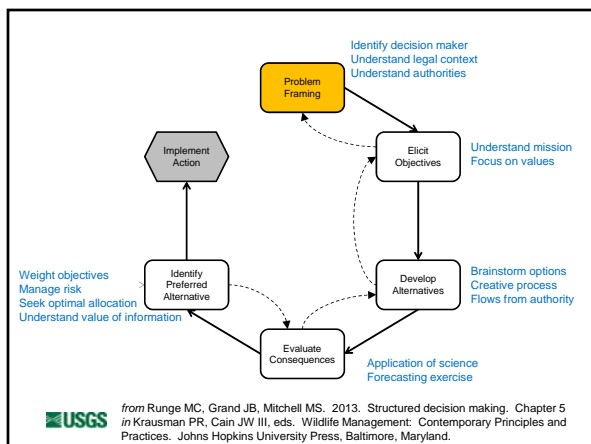
- Formal methods of decision analysis helped to
 - Structure the entire analysis
 - Articulate objectives & performance metrics
 - Develop alternatives
 - Explicitly express uncertainty
 - Elicit values-preferences from stakeholders
 - Integrate the science and policy elements
 - Analyze the effects of uncertainty
- Comprehensive decision analysis (incl., MCDA, EVPI) included in the Environmental Impact Statement

Prescriptive Decision Analysis


Decision Analysis

- Descriptive decision analysis
 - Huge field (psychology, behavioral economics) that investigates how humans, in fact, make decisions
- Prescriptive decision analysis
 - aka normative or classical decision analysis
 - Huge field (economics, operations research, management science) that investigates how humans should make decisions

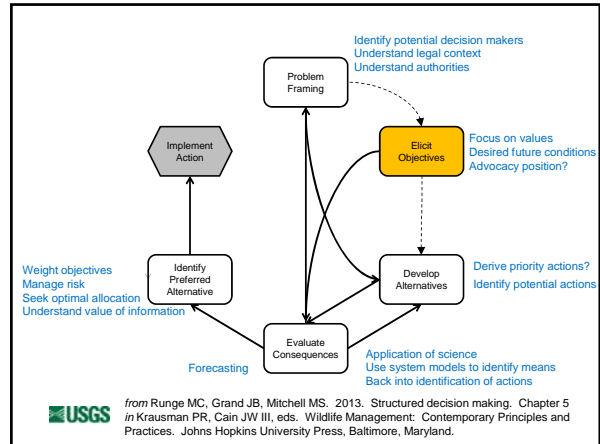
Prescriptive Decision Analysis

- Very large number of tools for framing and analyzing a decision problem
 - I've shown you one (MCDA) and briefly mentioned another (EVPI)
- The crux of this approach is understanding who the decision maker is, what their authority is, and what their mission is



Prospective Decision Analysis

What happens if you don't know who the decision maker could be?



Prospective Decision Analysis

- Not actually a new approach
 - This is how engineers approach design
- But an emerging paradigm in conservation planning
 - CBP, LCCs, TNC, SHC, SCP, OS
- Full suite of DA tools still applicable
- Crux, again, is identification of the decision makers who can take action

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