Toward Safer Consumer Products:
Exploring the Use of Multi-Criteria (MCDA) and Structured Decision Making (SDM) Approaches for Chemical Alternatives Assessment

Christian Beaudrie, Compass Resource Mgmt and U British Columbia
Charles J. Corbett, UCLA Anderson School of Management and
UCLA Institute of the Environment and Sustainability
Tom Lewandowski, Gradient; **Timothy Malloy**, UCLA School of Law
Xiaoying Zhou, California Department of Toxic Substances Control

November 1, 2018

compass UCLA SRA GRADIENT Department of Toxic Substances Control

Outline

- Alternatives Assessment
- Overview of decision approaches
- Workshop objectives and design
- Tentative findings

compass UCLA SRA GRADIENT Department of Toxic Substances Control

Example of AA: anti-fouling paint

Problem: Marine organisms attach to boat bottoms (fouling)

Current solution: copper-based paint (biocide)

Unintended consequences

Copper-based paint a "product of concern" => need an alternative

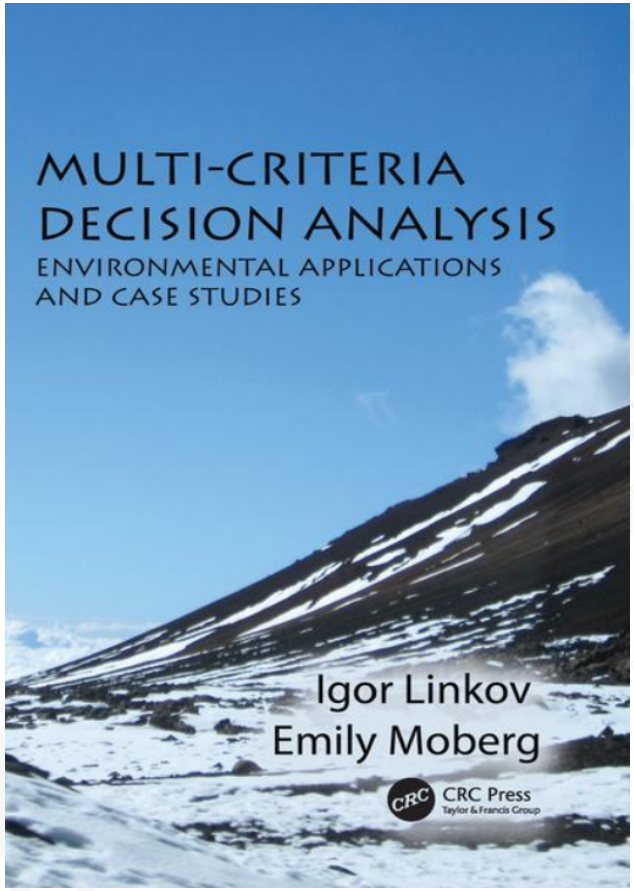
Alternatives Assessment: performance matrix

Decision Criteria		Performance Measure	Direction[1]	Potential Alternatives				
				HullSaver	StreamXL	Barrier	AquaSlide	Armor99
Human Health Concern[2]	Carcinogenicity[3]	4 pt scale	Higher	4	3	2	3	4
	Neurotoxicity (oral)[3]	mg/kg/day	Higher	0.5	700	50	75	0.5
	Reproductive/Developmental Toxicity (oral)[4]	mg/kg/day	Higher	100	0.01	250	175	0.01
	Respiratory Allergen/Asthmogen[4]	3 pt scale	Lower	2	1	1	3	1
Ecological Concern	PBTaq	percentage	Lower	10	40	40	10	5
	VOCs	grams/liter	Lower	1200	400	600	1300	200
Technical Performance	Longevity (time between needed applications)	Years	Higher	2	3	4	4	4
	Efficacy (performance in anti-fouling test)	5 pt scale	Higher	3	3	5	2	5
Cost	Cumulative 5 Year Cost (labor and materials)	Dollars	Lower	7,800	8,500	10,500	6,890	11,700

compass UCLA SRA GRADIENT Department of Toxic Substances Control

Can Multi-Criteria Decision Analysis help with environmental decisions?

- Wide range of methods
  - structuring problems
  - eliciting values
  - ranking alternatives
- Books and review articles
- But not tested yet in context of Alternatives Assessment



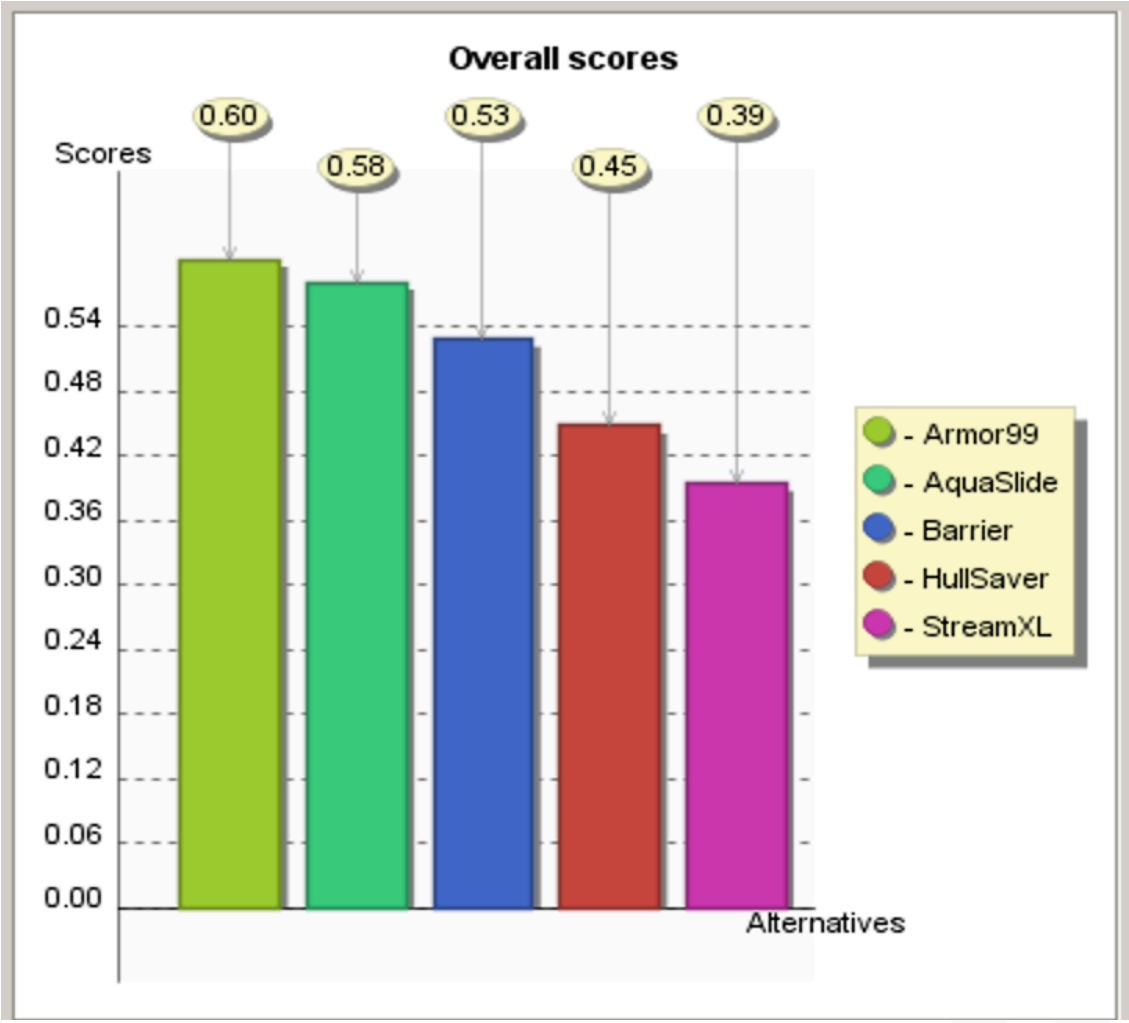
compass UCLA SRA GRADIENT Department of Toxic Substances Control

MCDA example: anti-fouling paint

Objectives	Evaluation Criteria	Weights		HullSaver		
Human Health Concern	Carcinogenicity	weight	X	performance	=	##
					+	
Ecological Concern	VOCs	weight	X	performance	=	##
					+	
Performance	Efficacy	weight	X	performance	=	##
					+	
Cost	Cumulative 5yr Cost	weight	X	performance	=	##

= Score (utility)

MCDA example: anti-fouling paint



Resulting values of alternatives

Armor99 score = 0.602
AquaSlide score = 0.581
Barrier score = 0.528
HullSaver score = 0.447
StreamXL score = 0.394

compass UCLA SRA GRADIENT Department of Toxic Substances Control

Structured Decision Making (SDM)

- Framework focused on **facilitated multi-stakeholder decision making**
- Provides guidance for structuring complex decisions
- Uses a combination of Decision Analytic tools
- Dialogue – promote understanding values, information, and trade-offs
- Evaluate trade-offs first, simplify decision, MCDA if a decision can't be made

Workshop Objectives

- To explore the value of formal decision-making tools to support chemical Alternatives Assessment (AA),
- To identify challenges in the use of decision-making tools by AA practitioners, and opportunities for improvement,
- To share these findings widely for the benefit of risk analysts and practitioners

Design

Three decision approaches: **'Default'** vs. **MCDA** vs. **SDM**

Variables:

Individual vs. small group vs. large group

Non-facilitated vs. facilitated

Max100, swing-weighting, SMARTER

Exercises:

1. **Individual 'Default' decision approach**
2. **Individual MCDA** (DECERNS) - not facilitated
3. **Group MCDA** (DECERNS) – light facilitation
4. **Group SDM (Structured Decision Making; Compass tools)** - facilitated

Participants

Practitioner focus – 12 in total:

- 3 from large US corporations
- 3 from small to mid-sized US corporation
- 3 from non-governmental organizations
- 2 from government (state, federal)
- 1 from risk consulting

- Observers from California EPA DTSC and UCLA Institute of the Environment and Sustainability

compass UCLA SRA GRADIENT Department of Toxic Substances Control

Survey 'Decision Quality' questions

- **Satisfied** with the approach?
- **Difficulty** of applying the approach?
- Did it improve your **understanding of**
  - **available information**?
  - **your own values?**
  - **key trade-offs?**
- How **transparent** is the approach?
- Could the approach help you better **communicate your decision and rationale**?
- How **comfortable** are you applying the approach to other decisions?
- **Would you use** the approach for chemical alternatives assessment?
- How **satisfied** are you with your **decision**?
- Does the decision outcome **reflect what matters** to you?
- Does the outcome **align with your initial impression** about what is the best alternative?

compass UCLA SRA GRADIENT Department of Toxic Substances Control

The AA case study: anti-fouling paint

Constructed 3 sets of alternatives, fictional but based on "Washington State Antifouling Boat Paint Alternatives Assessment Report" (2017)

Northwest Green Chemistry

- prior to workshop: individual, followed by survey
- in workshop: MCDA, followed by survey and discussion
- in workshop: SDM, followed by survey and discussion

- **Human health concerns**: carcinogenicity, neurotoxicity (oral), repro/ developmental toxicity (oral), respiratory allergen
- **Ecological concerns**: PBTaq (Persistence, Bioaccumulation, Aquatic Toxicity), VOCs
- **Technical performance**: longevity, efficacy
- **Cost**: cumulative 5-year cost

compass UCLA SRA GRADIENT Department of Toxic Substances Control

Performance matrix: 'Default' Exercise

Decision Criteria		Performance Measure	Direction[1]	Potential Alternatives				
				CerSmooth	SlipCote	Zn2000	Expedition	NoFoul
Human Health Concern[2]	Carcinogenicity[3]	4 pt scale	Higher	4	4	3	2	3
	Neurotoxicity (oral)[3]	mg/kg/day	Higher	50	500	250	10	0.5
	Reproductive/Developmental Toxicity (oral)[3]	mg/kg/day	Higher	200	20	70	0.5	0.01
	Respiratory Allergen/Asthmogen[4]	3 pt scale	Lower	1	1	2	2	2
Ecological Concern	PBTaq	100 pt scale	Lower	0	20	40	30	65
	VOCs (emissions during application)	grams/liter	Lower	150	100	300	250	270
Technical Performance	Longevity (time between needed applications)	Years	Higher	2	3			
	Efficacy (performance in anti-fouling test)	5 pt scale	Higher	3	3			
Cost	Cumulative 5 Year Cost (labor and materials)	Dollars	Lower	14,000	11,000			

Performance matrix: MCDA Exercise

Decision Criteria		Performance Measure	Direction[1]	Potential Alternatives				
				HullSaver	StreamXL	Barrier	AquaSlide	Armor99
Human Health Concern[2]	Carcinogenicity[3]	4 pt scale	Higher	4	3	2	3	4
	Neurotoxicity (oral)[3]	mg/kg/day	Higher	0.5	700	50	75	0.5
	Reproductive/Developmental Toxicity (oral)[3]	mg/kg/day	Higher	100	0.01	250	175	0.01
	Respiratory Allergen/Asthmogen[4]	3 pt scale	Lower	2	1	1	3	1
Ecological Concern	PBTaq	percentage	Lower	10				
	VOCs	grams/liter	Lower	1200	4			
Technical Performance	Longevity (time between needed applications)	Years	Higher	2				
	Efficacy (performance in anti-fouling test)	5 pt scale	Higher	3				
Cost	Cumulative 5 Year Cost (labor and materials)	Dollars	Lower	7,800	8,5			

Performance matrix: SDM Exercise

Decision Criteria		Performance Measure	Direction[1]	Potential Alternatives				
				Blast199	Thi2	Barracuda	Barracuda	GuardX3
Human Health Concern[2]	Carcinogenicity[3]	4 pt scale	Higher	3	4	2	3	4
	Neurotoxicity (oral)[3]	mg/kg/day	Higher	50	10	70	Data Gap	1
	Reproductive/Developmental Toxicity (oral)[3]	mg/kg/day	Higher	80	200	10	175	60
	Respiratory Allergen/Asthmogen[4]	3 pt scale	Lower	2	3	1	Data Gap	1
Ecological Concern	PBTaq	Percentage	Lower	60	60	50	10	2
	VOCs	gram/liter	Lower	400	100	1300	300	900
Technical Performance	Longevity (time between needed applications)	Years	Higher	4	3	4	3	4
	Efficacy (performance in anti-fouling test)	5 pt scale	Higher	5	3	5	4	5
Cost	Cumulative 5 Year Cost (labor and materials)	Dollars	Lower	9,000	4,000	4,200	8,000	11,000

compass UCLA SRA GRADIENT CalEPA Department of Toxic Substances Control

’Default’ decision-making styles

Narrative Approaches (4)

Holistic, qualitative balancing of the data and associated trade-offs to arrive at a selection

Widely used in regulatory decision-making

Rule-Based (3)

More systematic, may use rules or tools like decision trees etc.

May use quantitative and qualitative data, may incorporate implicit or explicit weighting of the decision criteria

MCDA-Assist (1)

Couples a narrative evaluation with a mathematically-based formal decision analysis tool such as multi-criteria decision analysis (MCDA)

Hybrid Approach (4)

Mix of rule-based and narrative

compass UCLA SRA GRADIENT Department of Toxic Substances Control

“Survey” results

	DEFAULT	MCDA IND.	MCDA GROUP	SDM
Improved understanding of your own values	3.3	3.8	3.9	3.8
Improved understanding of available information	3.3	3.4	3.6	3.6
Improved understanding of the trade-offs btw alternatives	3.3	4.4	3.9	4.0
Enables or promotes transparency	3.4	3.8	2.7	3.8
Could help you communicate results and decision rationale	3.7	4.0	2.9	4.0
Difficulty of applying decision-making approach	3.5	4.0	3.3	3.8
Difficulty of applying weighting method	3.0	4.2	3.0	4.1
Top alternative aligns with your intuition or gut	2.9	3.4	1.6	3.5
Top alternative reflects what matters to you	3.9	3.8	1.6	3.7
Satisfied with decision approach	3.9	4.0	2.6	4.0
Satisfied with the decision you made	3.6	4.4	2.1	3.5
Comfortable applying approach to other chemical AA decisions	3.2	3.6	2.4	3.7
Likely that your institution would use the approach	3.5	3.4	2.9	3.3

General Observations

- Range of "default" decision approaches, mostly narrative / rule-based
- MCDA and SDM help improve understanding (of information, values, trade-offs), enhance transparency and communication
- Group dynamics and facilitation matter: individuals satisfied with MCDA, group rejected MCDA outcome
- Surprises:
  - satisfaction with approach =/= satisfaction with decision
  - somewhat more comfortable using MCDA/SDM but not more likely to use
- Other comments:
  - hands-on with tools, time to explore weights and sensitivities valuable
  - some discomfort with compensatory nature of utility model
  - some participants wanted data on baseline

compass UCLA SRA GRADIENT Department of Toxic Substances Control

Conclusions

- More formal decision support can help in Alternatives Assessment, but unclear how best to use or evaluate
- Users may not be more satisfied with decisions made using a process they are more satisfied with

  => how do we measure “success”?
- Idiosyncratic factors (e.g., facilitation, group dynamics) can play a big role
- Much more guidance needed on how to use MCDA/SDM methods in practice

compass UCLA SRA GRADIENT Department of Toxic Substances Control

Acknowledgements

- Society for Risk Analysis and UCLA – workshop funding and support

- Special thanks to:
  - Amelia and Lauren at Northwest Green Chemistry
  - Karla Vasquez, UCLA

Northwest Green Chemistry
Solutions for sustainable prosperity

compass UCLA SRA GRADIENT Department of Toxic Substances Control

Thank you!

Questions?