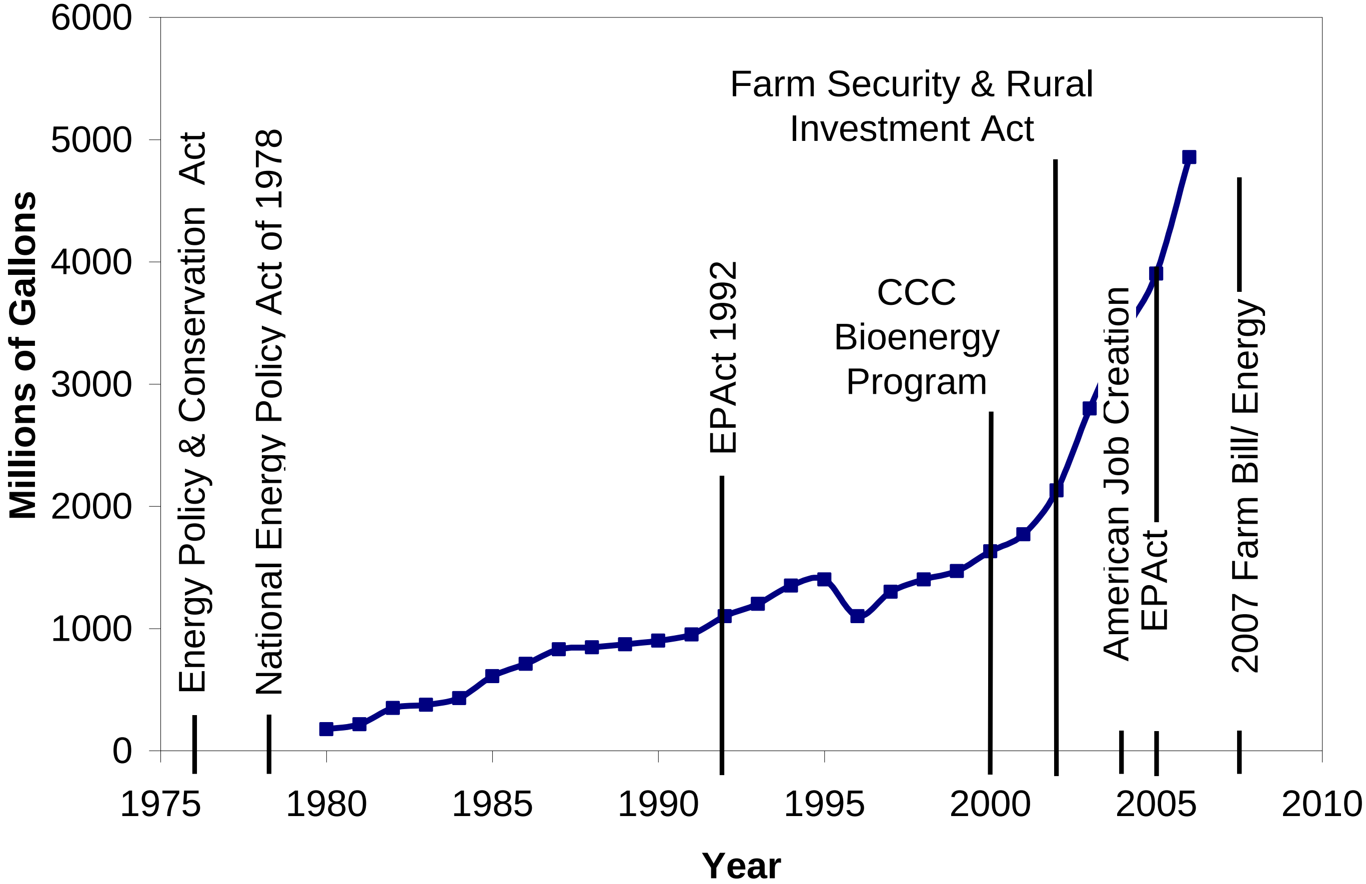


Ethanol Policies and Production. Federal incentives and mandates have been instrumental in increasing ethanol production.

Data compiled by Amanda Malone, MS
Science, Technology & Public Policy, RIT

POINT / COUNTERPOINT

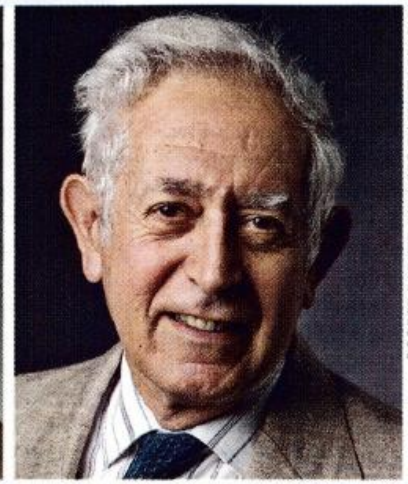
The Costs Of Biofuels

Two views on whether corn ethanol and, eventually, ethanol from cellulosic biomass will efficiently deliver **NATIONAL ENERGY SECURITY**

THE DRUMBEAT in favor of biofuels has only increased since President George W. Bush's 2007 State of the Union address calling for a 20% cut in gasoline use, much of it to be replaced with alternative fuels such as biofuels. Indeed, industry has begun investing in biofuels and biofuels R&D as never before. Consumers, too, are eager for anything that might trim the cost of a gallon of gasoline.

But the criticisms and questions that dog the use of biofuels remain formidable. Can the U.S. really afford to devote its entire corn crop to the production of ethanol, as might be required under some of the targets set by Presi-

KURT STEPNITZ/MSU COMMUNICATIONS



ROBERT BARKER/UNIVERSITY PHOTOGRAPHY

DEBATES Dale (left), a chemical engineering professor at Michigan State University, contends that well-chosen metrics need to be used in order to evaluate the true costs and benefits of biofuels; Pimentel, an entomologist and professor of agricultural sciences at Cornell University, argues that biofuels are costly from both economic and environmental perspectives and also raise significant ethical concerns.

tional to support or oppose biofuels without relevant performance standards than it is to support or oppose ballpoint pens without appropriate criteria. Therefore, what are the appropriate comparison standards for biofuels?

Two issues are pivotal for all petroleum alternatives: national security by significantly reducing petroleum dependence and climate security by significantly reducing greenhouse gases. Biofuels should substantially reduce petroleum used and greenhouse gases generated compared with their petroleum-derived alternatives. Ideal biofuel metrics are petroleum consumed and greenhouse gases generated per mile

Atmos. Chem. Phys. Discuss., 7, 11191–11205, 2007
www.atmos-chem-phys-discuss.net/7/11191/2007/

Atmospheric Chemistry and Physics Discussi

For Official Use

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

GENERAL SECRETARIAT

SG/SD/R
For Offic

N_2O release from agro-biofuel productio negates global warming reduction by replacing fossil fuels

This study draws on 47 published assessments that compare bio-ethanol systems to conventional fuel on a life cycle basis, or using life cycle assessment (LCA). A majority of these assessments focused on net energy and greenhouse gases, and despite differing assumptions and system boundaries, the following general lessons emerge: (i) make ethanol from sugar crops, in tropical countries, but approach expansion of agricultural land usage with extreme caution; (ii) consider hydrolysing and fermenting lignocellulosic residues to ethanol; and (iii) the LCA results on grasses as feedstock are insufficient to draw conclusions. It appears that technology choices in process residue handling and in fuel combustion are key, whilst site-specific environmental management tools should best handle biodiversity issues. Seven of the reviewed studies evaluated a wider range of environmental impacts, including resource depletion, global warming, ozone depletion, acidification, eutrophication, human and ecological health, smog formation, etc., but came up with divergent conclusions, possibly due to different approaches in scoping. These LCAs typically report that bio-ethanol results in reductions in resource use and global warming; however, impacts on acidification, human toxicity and ecological toxicity, occurring mainly during the growing and processing of biomass, were more often unfavourable than favourable. It is in this area that further work is needed.

Sciencexpress

Paris, 11-12 September 2007

Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change

Timothy Searchinger,[1*] Ralph Heimlich,[2] R. A. Houghton,[3] Fengxia Dong,[4] Amani Elobeid,[4] Jacinto Fabiosa,[4] Simla Tokgoz,[4] Dermot Hayes,[4] Tun-Hsiang Yu[4]

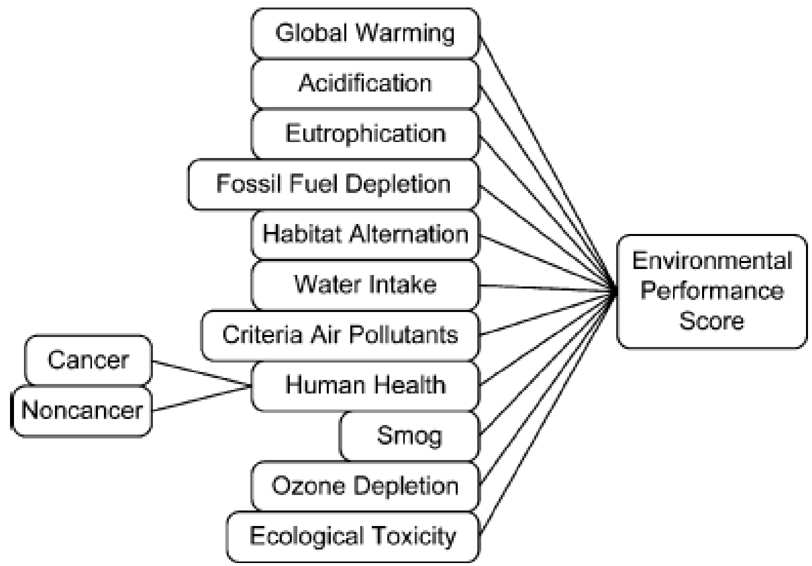
Critical Review

Critical Analysis of the Mathematical Relationships and Comprehensiveness of Life Cycle Impact Assessment Approaches

JANE C. BARE[†] AND THOMAS P. GLORIA[‡]

U.S. Environmental Protection Agency, National Risk Management Laboratory, Cincinnati, Ohio 45268. Phone: 513-569-7513. FAX: 5. Email: bare.jane@epa.gov and ICF Consulting, 33 Hayden Avenue, Massachusetts 02421 Email: tgloria@icfconsulting.com

The impact assessment phase of Life Cycle Assessment (LCA) has received much criticism due to lack of consistency. While the ISO standards for LCA did make great strides in advancing the consensus in this area, ISO is not prescriptive, but has left much room for innovation and therefore inconsistency. To address this lack of consistency, there



Environ. Sci. Technol. **2007**, *41*, 7551–7557

Life Cycle Impact Assessment Weights to Support Environmentally Preferable Purchasing in the United States

THOMAS P. GLORIA,*,[†]
BARBARA C. LIPPIATT,[‡] AND
JENNIFER COOPER[§]

cancerous effects (8%), ecological toxicity (7%), eutrophication of water bodies (6%), land use (6%), and human health noncancerous effects (5%). Also of interest are the identified impact areas of concern assigned the lowest weights: smog formation (4%), indoor air quality (3%), acidification (3%), and ozone depletion (2%). Their low weights may indicate that there is not as much immediate concern or that the remedial actions associated with the impact for the most part are underway.

Normalization

"Normalization is the calculation of the magnitude of the category indicator results relative to some reference information. The aim of the normalization is to understand better the relative magnitude for each indicator results of the products system under study"

ISO 14044:2006

Normalization by:

1. Area of reference
2. Area of reference per capita
3. Baseline scenario (other alternatives)

External

Internal

International Organization for Standardization

iso.org

Norris, 2001, Lautier et al., 2010

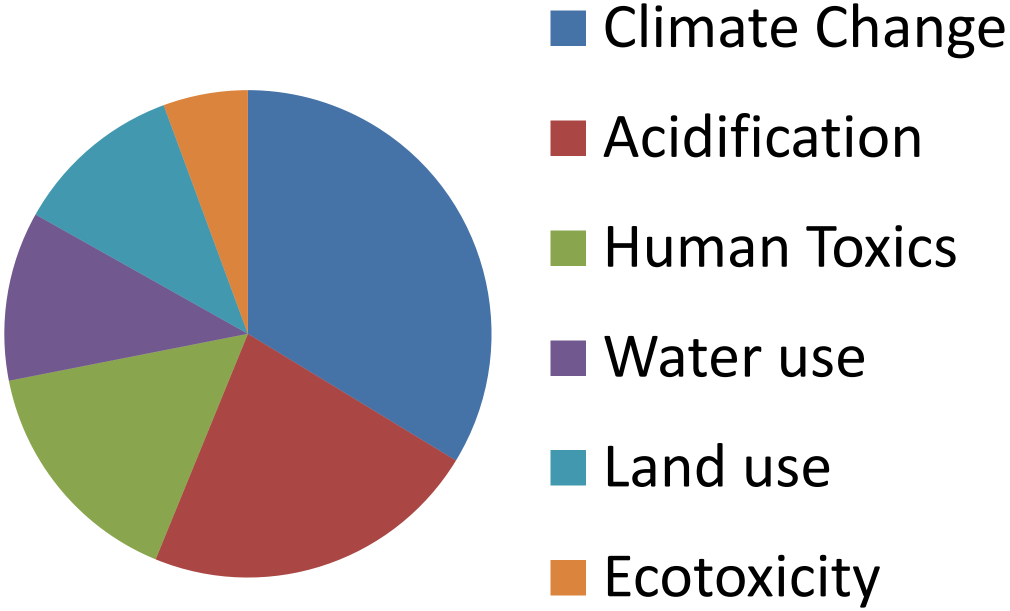
Weighting

$$\sum w_i = 100$$

"Weighting is the process of converting indicator results of different impact categories by using numerical factors based on value-choices"

ISO 14044:2006

Decision maker A:



Voting Interests of Individuals Invited to Participate in BEES Stakeholder Panel

The three general classifications of individuals invited to participate in the BEES stakeholder panel included:

- Producer – An individual who represents an organization that produces or sells building materials, products, systems or services
- User – An individual who purchases or represents an organization that purchases or uses building materials, products, systems or services
- LCA Expert – An individual who does not fit into any of the preceding categories *and* is recognized for his/her LCA expertise

* *classifications adapted from ASTM International*

FIGURE 2. Voting interests of participants.

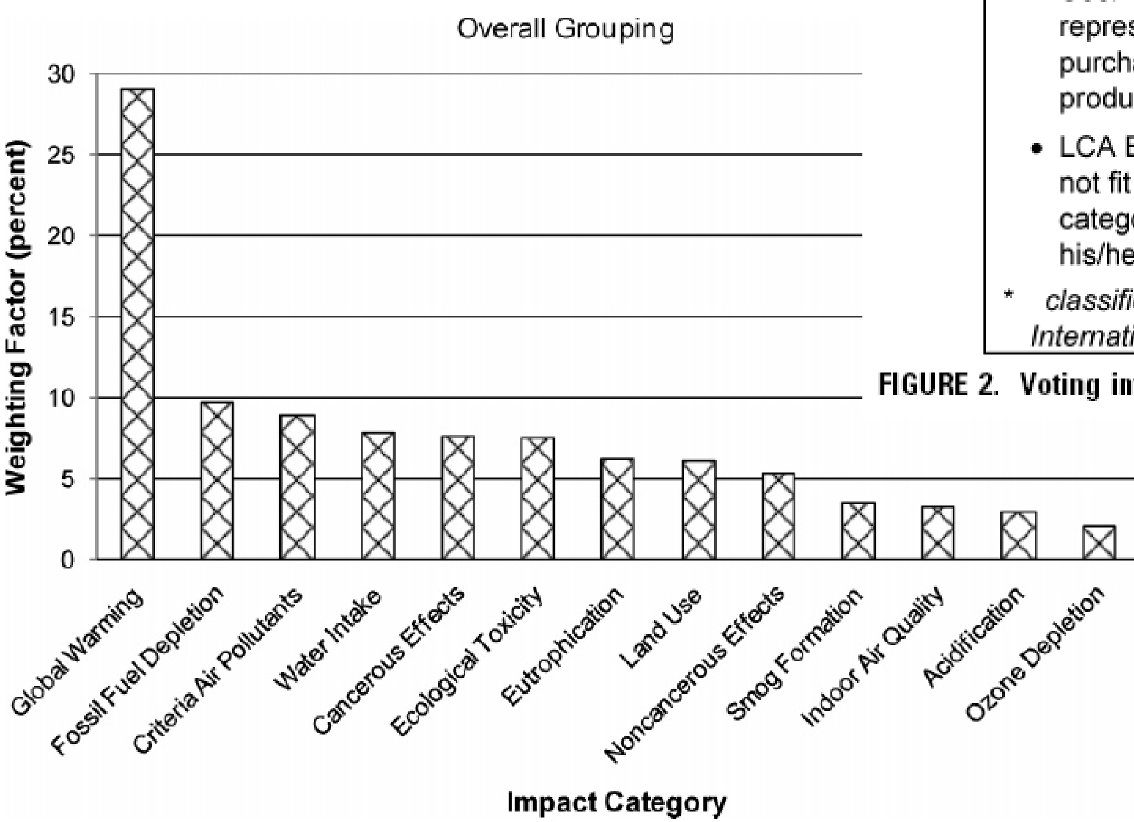
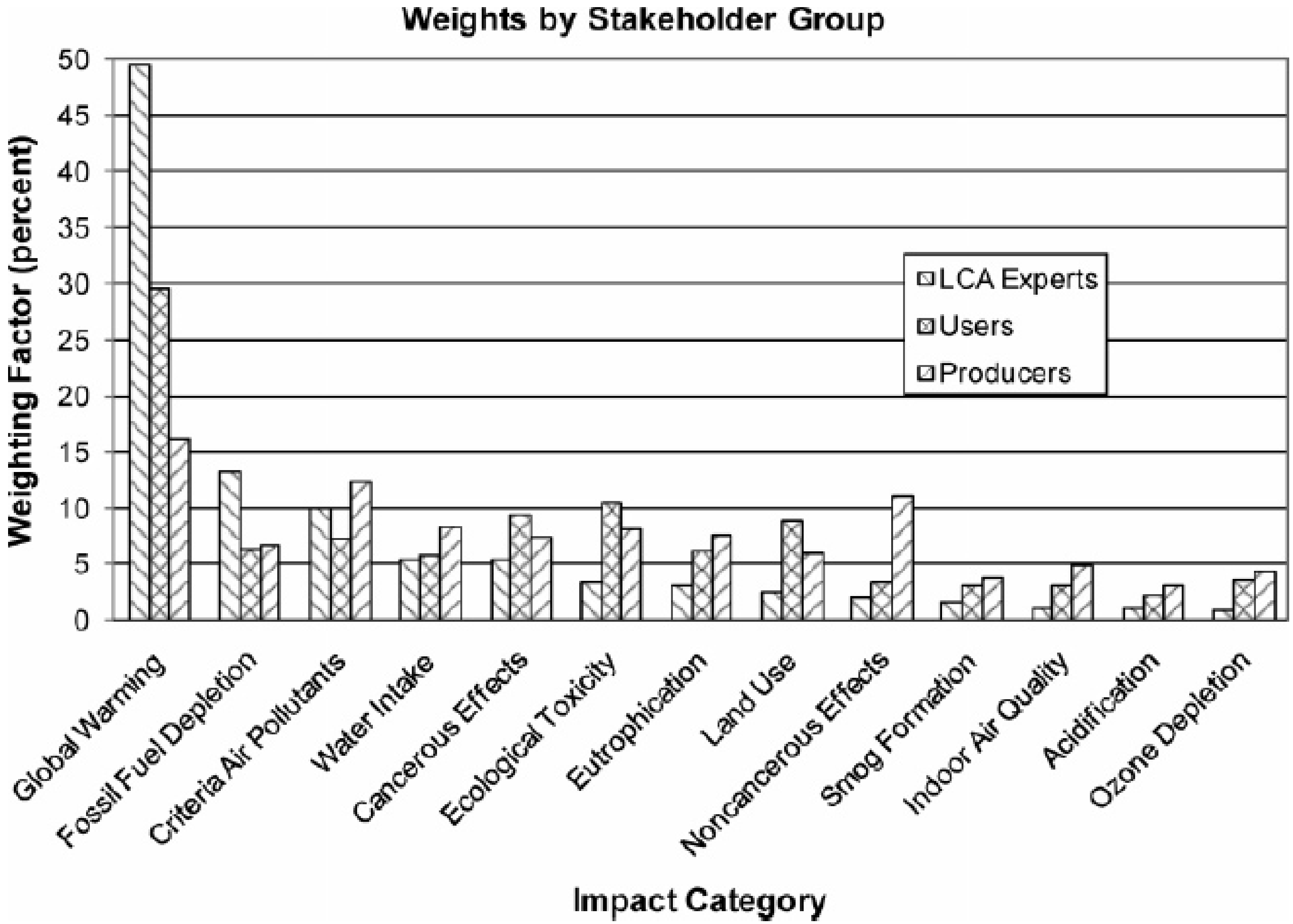


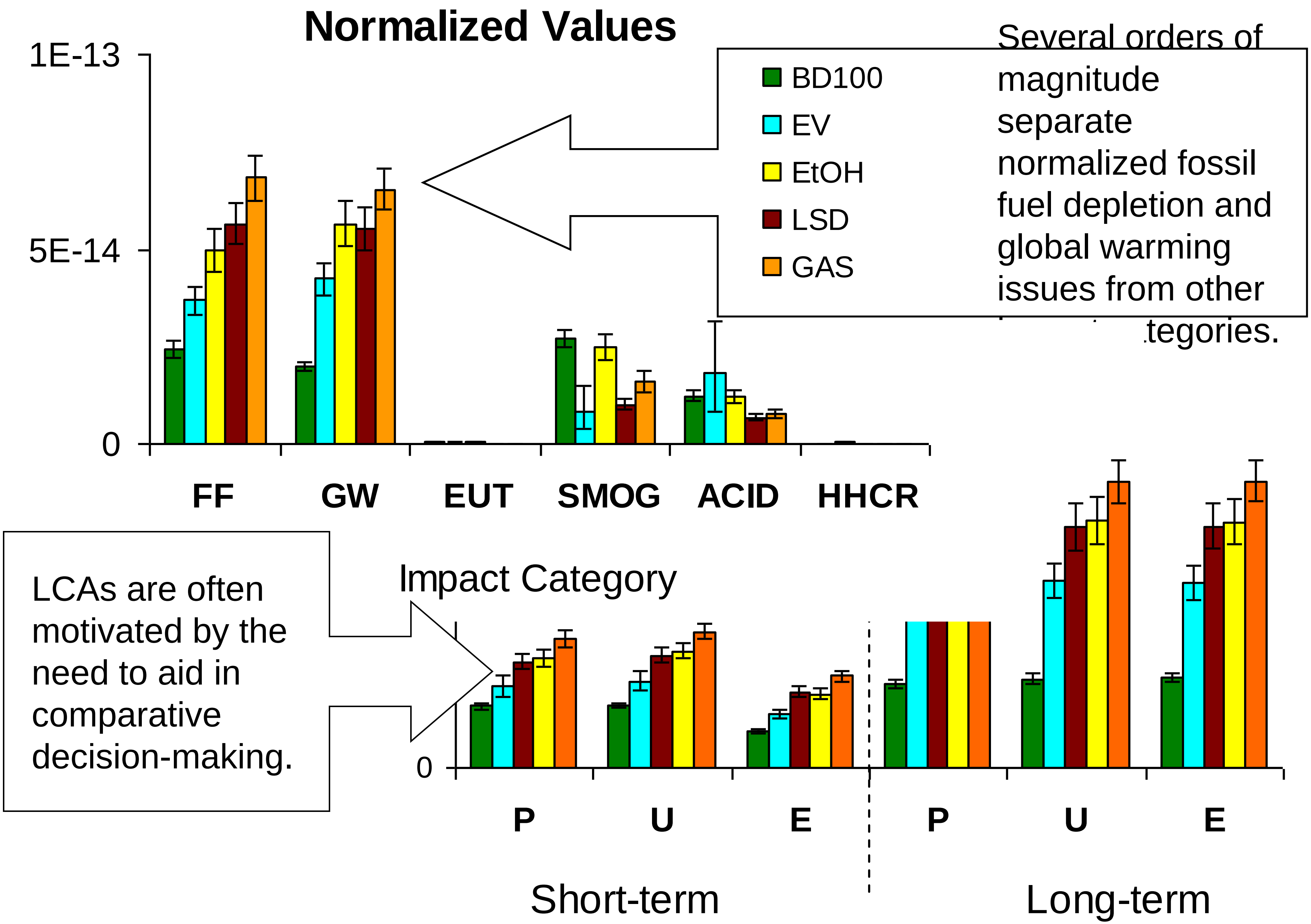
FIGURE 1. General environmentally preferable purchasing weights.



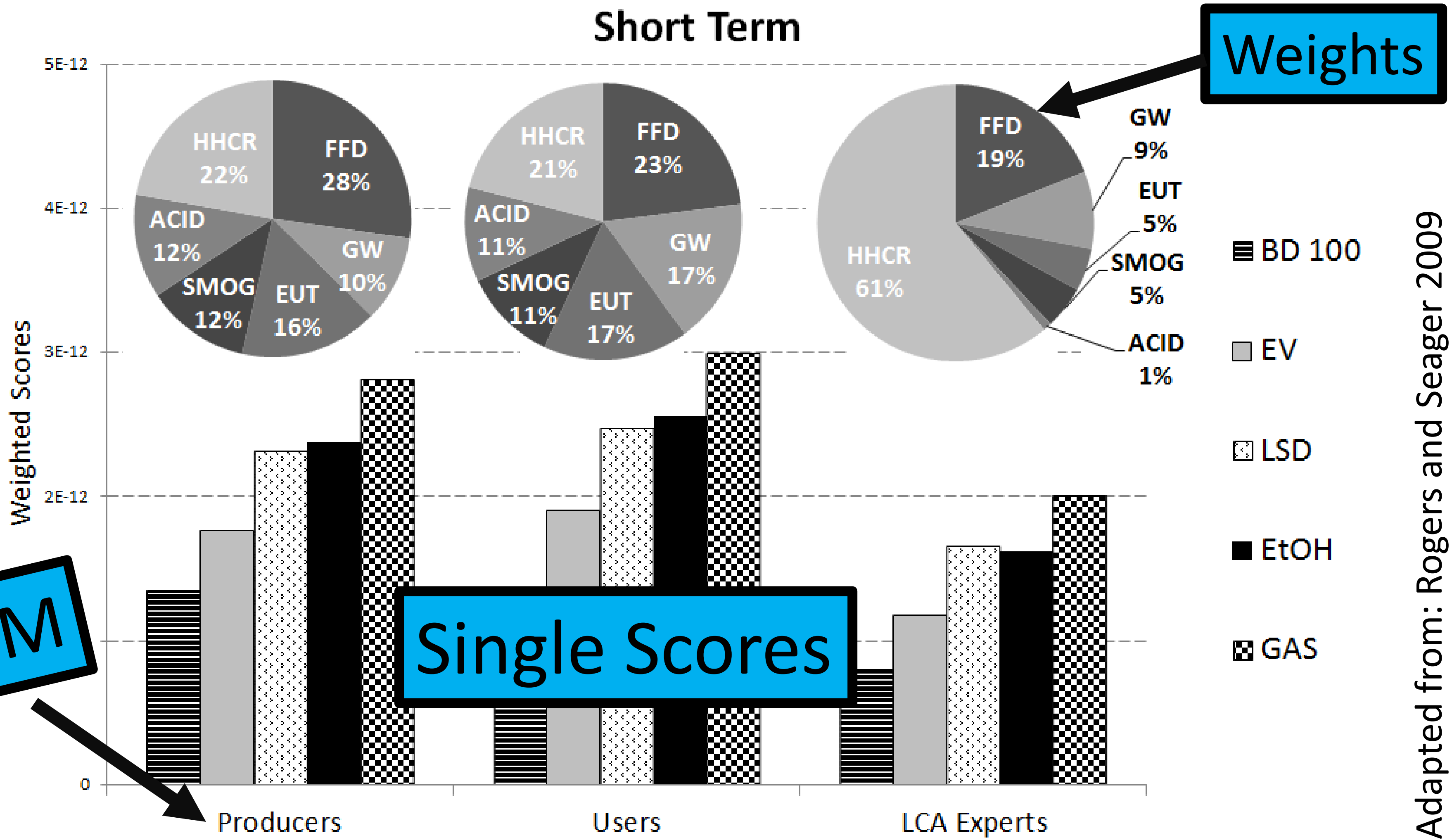
Weights by Stakeholder Group
Weighting Factor (percent)
0
5
10
15
20
25
30
35
40
45
50
LCA Experts
Users
Producers
Global Warming
Fossil Fuel Depletion
Criteria Air Pollutants
Water Intake
Cancerous Effects
Ecological Toxicity
Eutrophication
Land Use
Noncancerous Effects
Smog Formation
Indoor Air Quality
Acidification
Ozone Depletion
Impact Category

TABLE 3. Environmental Impact Importance (%) by Voting Interest and Time Horizon

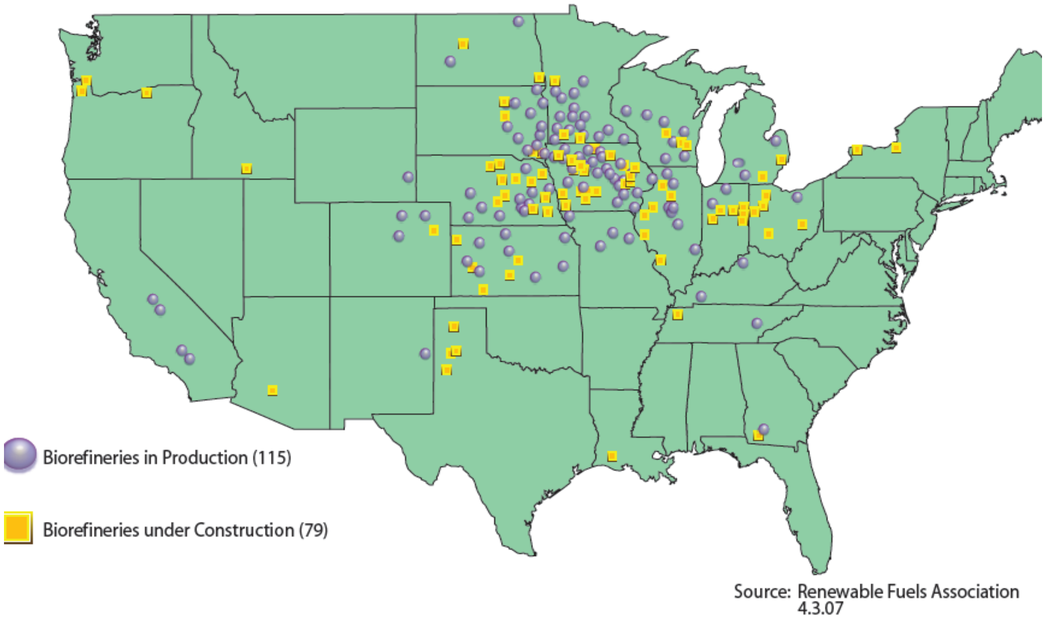
	all time horizons (100%)				short-term time horizon (24%)				medium-term time horizon (31%)				long-term time horizon (45%)			
impact category	all	producer	user	LCA expert	all	producer	user	LCA expert	all	producer	user	LCA expert	all	producer	user	LCA expert
global warming	29	16	30	50	7	5	9	7	43	26	43	60	52	30	57	68
fossil fuel depletion	10	12	7	10	15	13	12	15	7	13	3	13	4	10	1	5
criteria air pollutants	9	7	6	13	18	11	11	48	2	3	3	1	1	2	0	1
water intake	8	7	10	5	7	7	8	3	10	8	14	6	8	8	9	6
cancerous	8	8	6	6	8	11	6	5	6	4	6	4	9	9	6	7
ecological toxicity	8	8	11	3	6	5	9	2	9	12	11	3	9	9	13	5
eutrophication	6	8	6	3	8	8	9	4	6	10	5	5	3	4	2	2
land use	6	6	9	3	7	7	11	3	6	6	8	3	5	6	6	3
noncancerous	5	11	4	2	6	12	5	3	4	6	2	2	6	17	2	2
smog formation	4	4	3	2	7	6	6	4	1	3	1	1	0	1	0	1
indoor air quality	3	5	3	1	7	9	6	4	1	1	1	1	0	0	0	0
acidification	3	4	4	1	4	6	6	1	2	4	2	1	2	2	2	1
ozone depletion	2	3	2	1	2	3	3	1	2	4	2	1	2	3	1	1
inconsistency	0.03	0.05	0.03	0.05	0.04	0.06	0.06	0.05	0.02	0.04	0.02	0.06	0.06	0.11	0.08	0.13

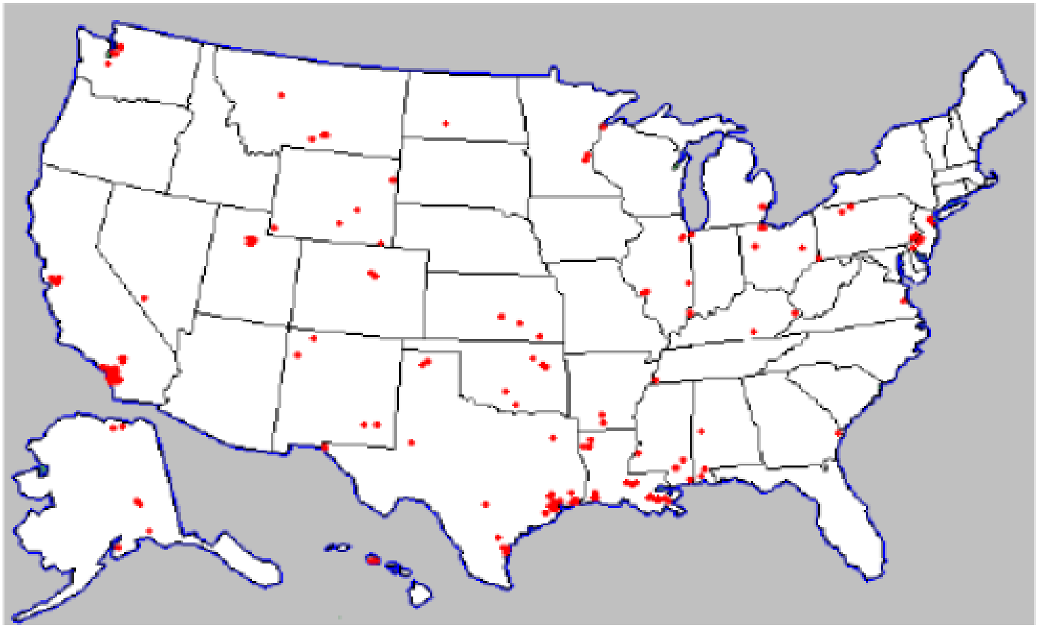

Normalized Values
1E-13
5E-14
0
BD100
EV
EtOH
LSD
GAS
Several orders of magnitude separate normalized fossil fuel depletion and global warming issues from other
tegories.
FF
GW
EUT
SMOG
ACID
HHCR
Impact Category
LCAs are often motivated by the need to aid in comparative decision-making.
0
P
U
E
P
U
E
Short-term
Long-term

Weighting Insensitivity



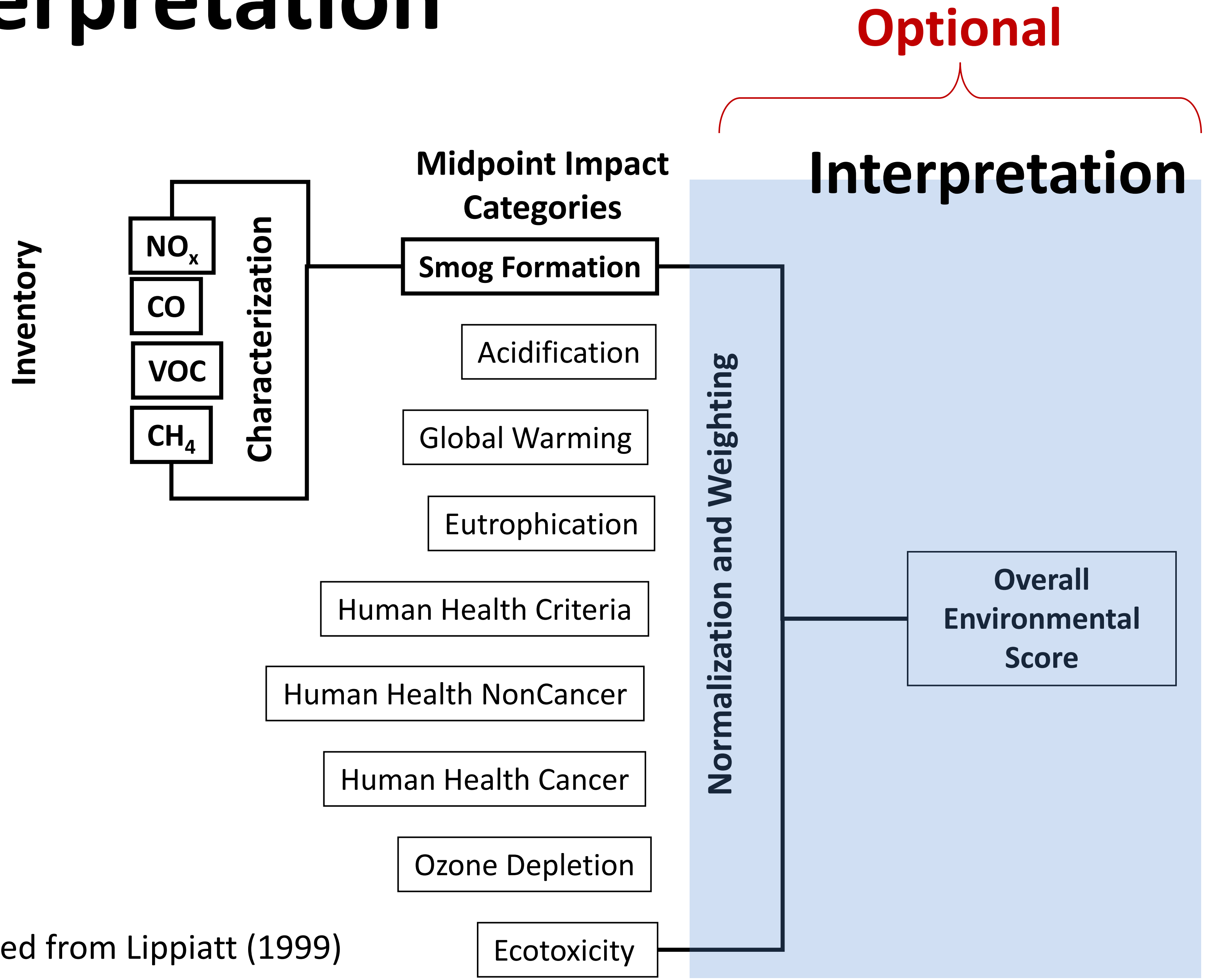
Adapted from: Rogers and Seager 2009





Geographic Distribution of Fuel Processing Facilities in the US. Petroleum refineries (bottom) are predominantly located on the coasts near major seaports – whereas biorefineries (top) are concentrated in the northern Midwest in the Corn Belt States. Consequently, federal biofuel mandates may be environmentally inefficient in some regions but favorable in others, depending upon transportation impacts.

Interpretation

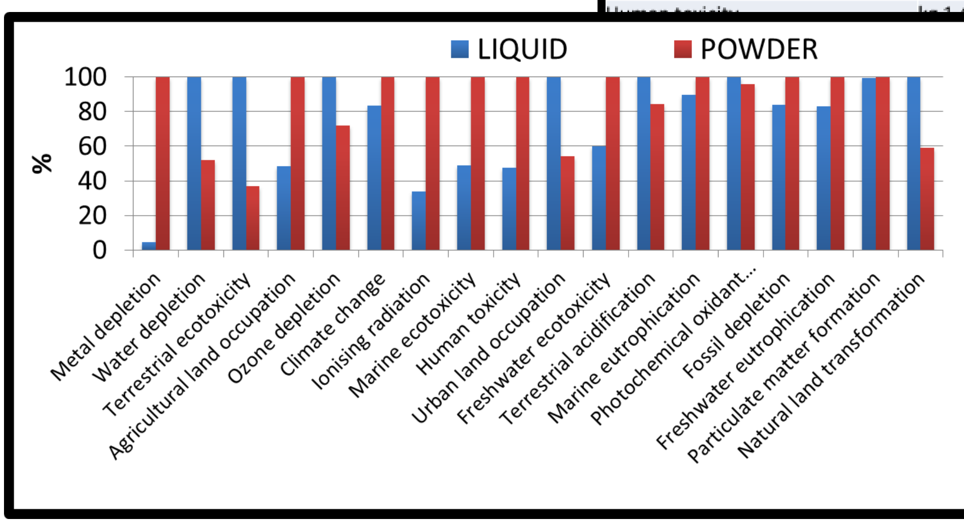


Adapted from Lippiatt (1999)

Analytic aid in result interpretation

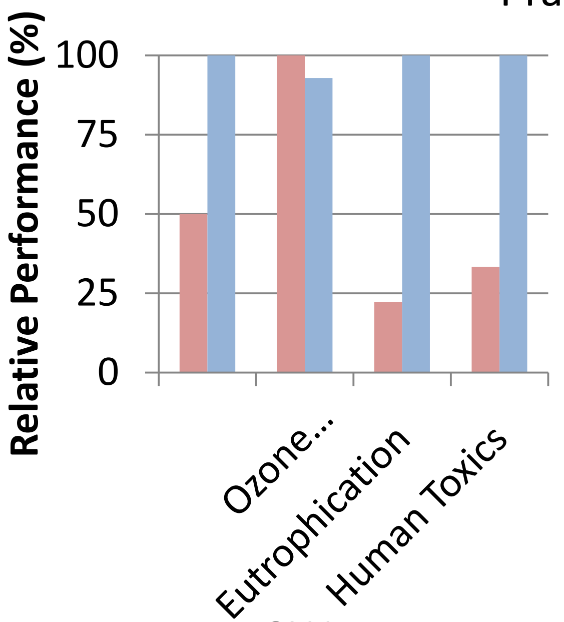
- Multiple indicators (different units)
- Multiple alternatives (Comparative Assessments)
- Uncertainty
- Decision Makers
- Environmental tradeoffs

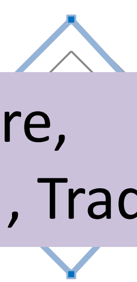
Impact category	Unit	LIQUID	POWDER
Metal depletion	kg Fe eq	0.000199	0.00443
Water depletion	m3	0.00266	0.00138
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000706	0.000262
Agricultural land occupation	m2a	0.0102	0.021
Ozone depletion	kg CFC-11 eq	9.24E-09	6.65E-09
Climate change	kg CO2 eq	0.090378177	0.102304355
Ionising radiation	kg U235 eq	0.00689	0.0203
Marine ecotoxicity	kg 1,4-DB eq	0.00051	0.00104
	DB eq	0.0195	0.041
		0.00143	0.000775
	DB eq	0.000702	0.00117
	eq	0.000518689	0.000436512
	q	7.05104E-05	7.92817E-05
	VOC	0.000306118	0.000289197
	eq	0.0329	0.0392
	q	0.0000349	0.000042
	10 eq	0.000159255	0.00015987
		0.0000195	0.0000115



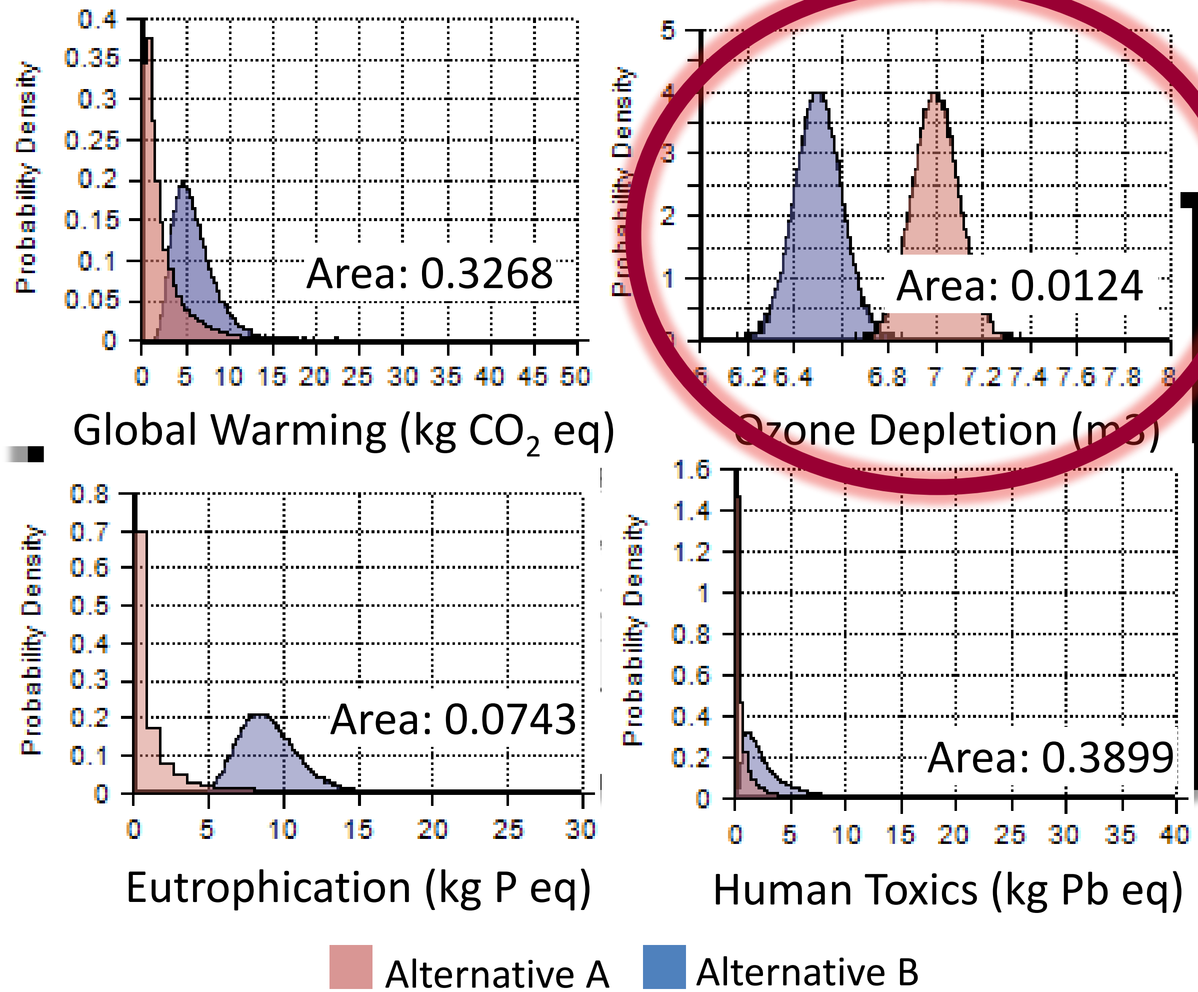
Trade-off Evaluation

Prado-Lopez V, Seager TP, Chester M, Laurin L, Arslan E (accepted)

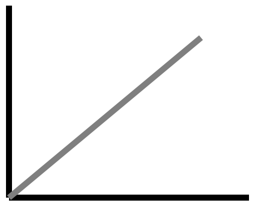




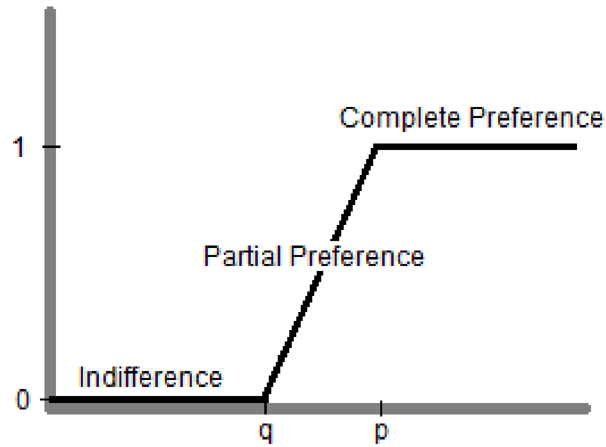
Therefore,
Area ↓ , Trade-off ↑



Compensation (linearity)



Weak sustainability perspective



Strong sustainability perspective

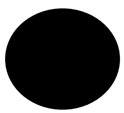
Full compensation

Partial compensation

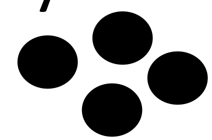
No compensation

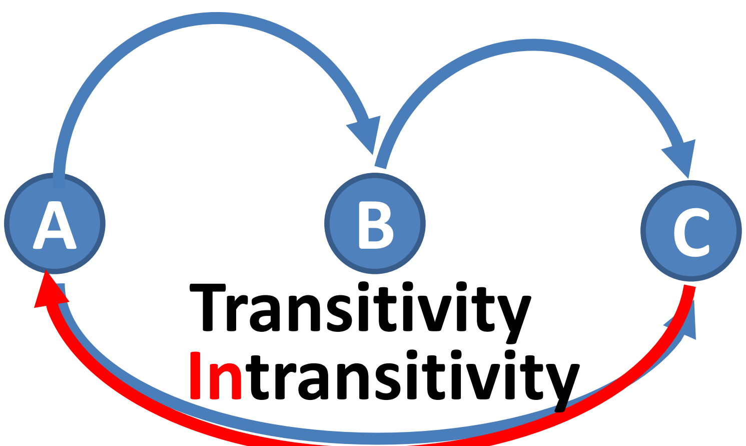
Absolute vs Relative

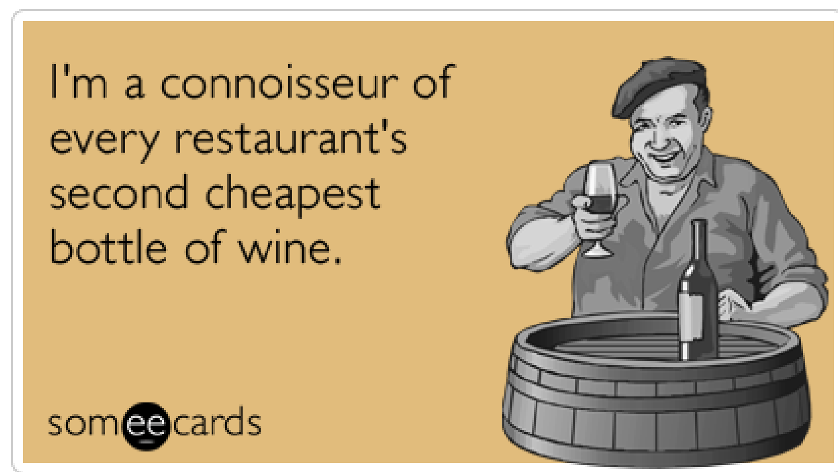
Normative (External)

- “should be”
- Absolute 
- Context free
- Transitivity

Descriptive (Internal)

- “How they are”
- Relative 
- Context effect
- Intransitivity



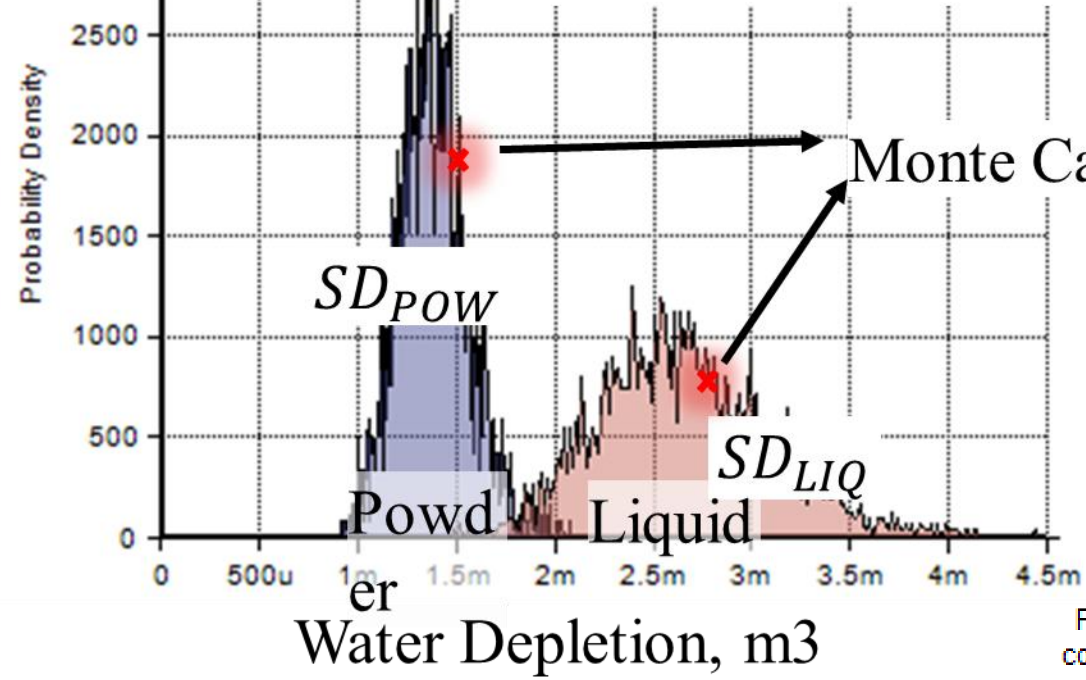


Prado et al., 2012

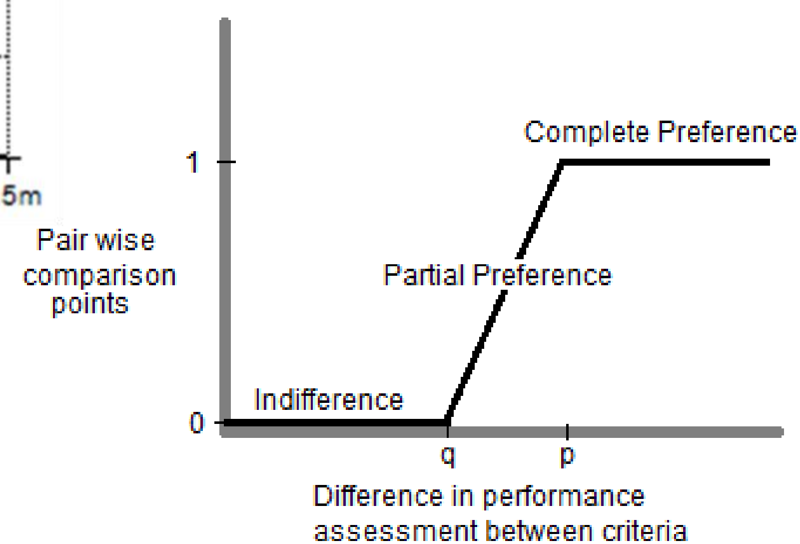
Stochastic Outranking

$$\text{Preference threshold, } p = \frac{SD_{LIQ}+SD_{POW}}{2}$$

$$\text{Indifference threshold, } q = \frac{p}{2}$$



Stochastic Multi attribute Analysis (SMAA)

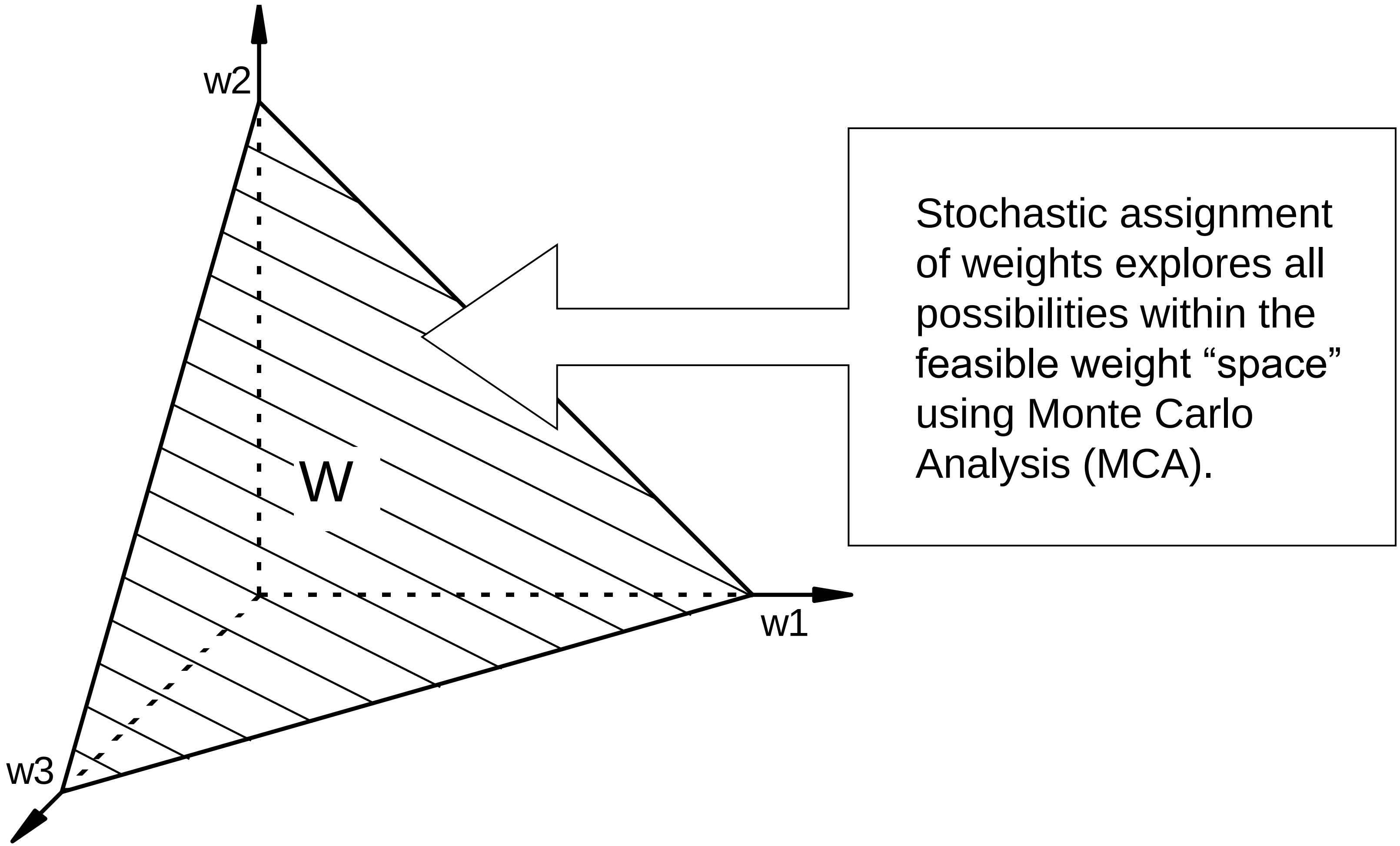


Pedigree Matrix

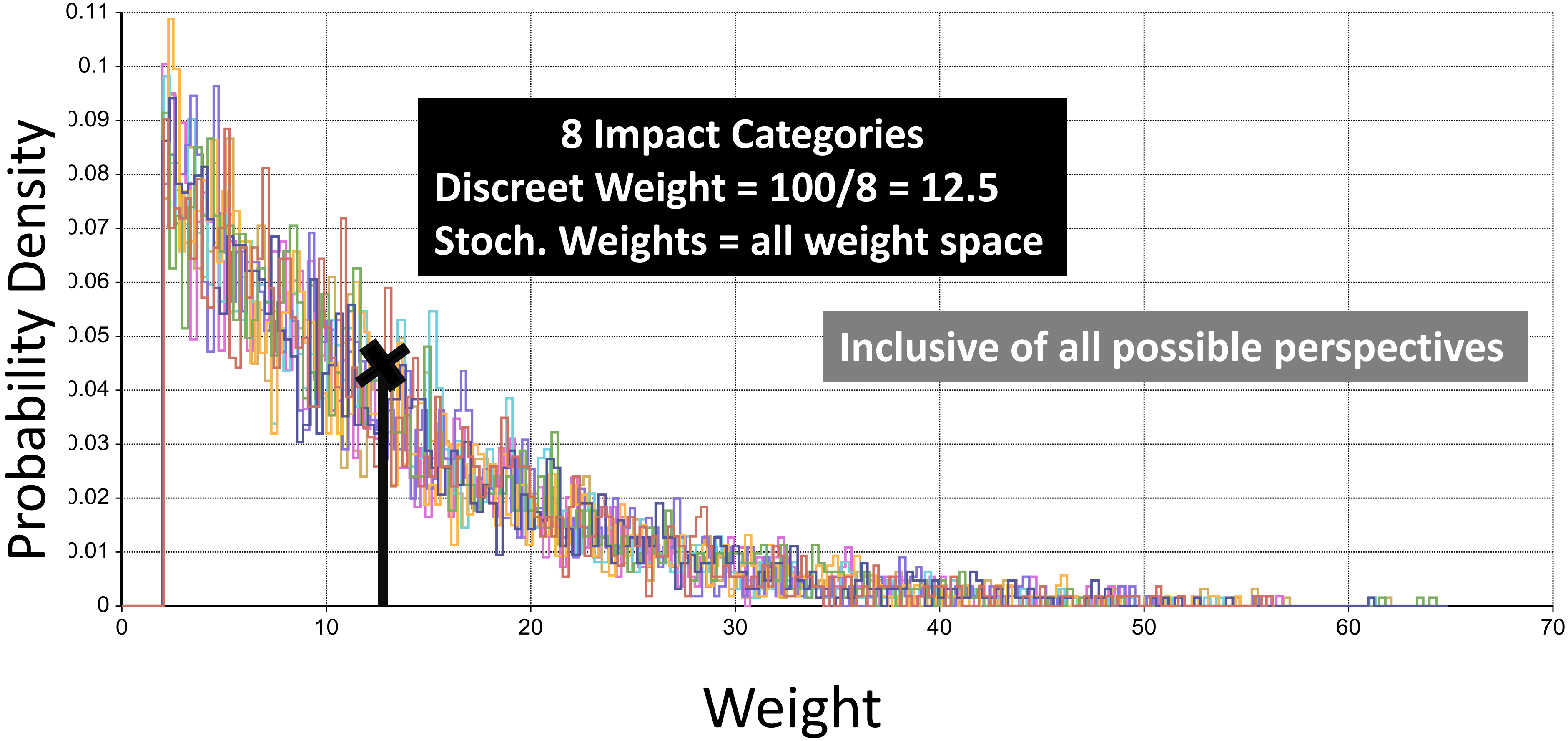
Table 3 – Pedigree matrix for managing cost data quality issues in eco-efficiency

Indicator score	1	2	3	4	5
Reliability of source	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions.	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate or unknown origin
Completeness	Representative data from a sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from a smaller number of sites but for adequate periods	Representative data from an adequate number of sites but from shorter periods	Representative data but from a smaller number of sites and shorter periods or incomplete data from an adequate number of sites and periods	Representativeness unknown or incomplete data from a smaller number of sites and/or from shorter periods
Temporal differences	Less than 0.5 years of difference to year of study	Less than 2 years difference	Less than 4 years difference	Less than 8 years difference	Age of data unknown or more than 8 years of difference
Geographical differences	Data from area under study, **same currency**	Average data from larger area in which the area under study is included, **same currency**	Data from area with slightly **similar cost conditions, same currency, or with similar cost conditions, and similar currency**	Data from area **with slightly similar cost conditions, different currency**	Data from unknown area or area with very **different cost conditions**
Further technological differences	Data from enterprises, processes, and materials under study	Data from processes and materials under study from different enterprises, **similar accounting systems**	Data from processes and materials under study but from different technology, **and/or different accounting systems**	Data on related processes or materials but same technology	Data on related processes or materials but different technology

http://cxdd.broceliande.kerbabel.fr/?q=node/449/226

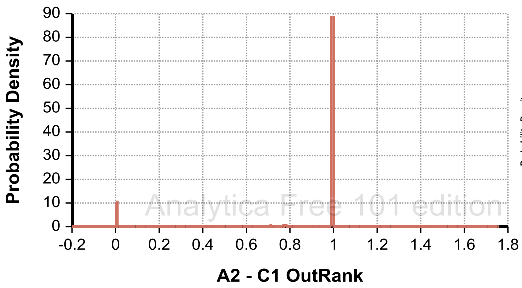

w2
w1
w3
W
Stochastic assignment of weights explores all possibilities within the feasible weight “space” using Monte Carlo Analysis (MCA).

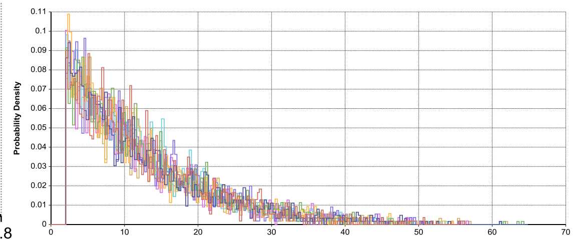
Stochastic **Weights**

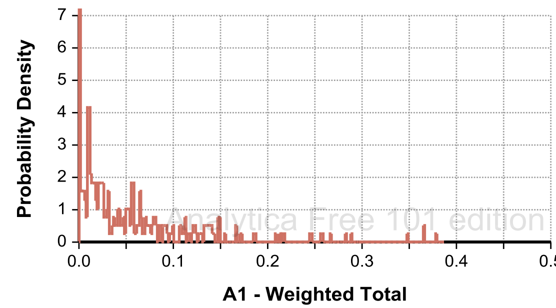


SMAA-LCA results

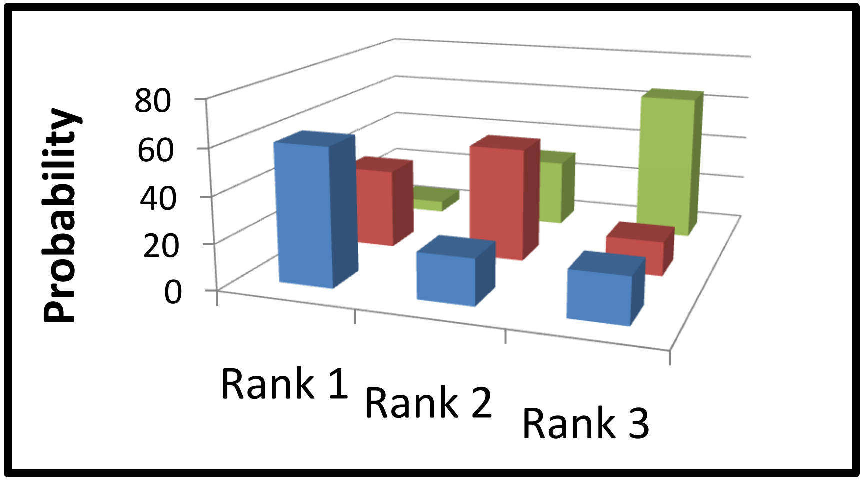
Stochastic Outranking * Stochastic Weight = Stochastic Overall Score







Probabilistic ranking

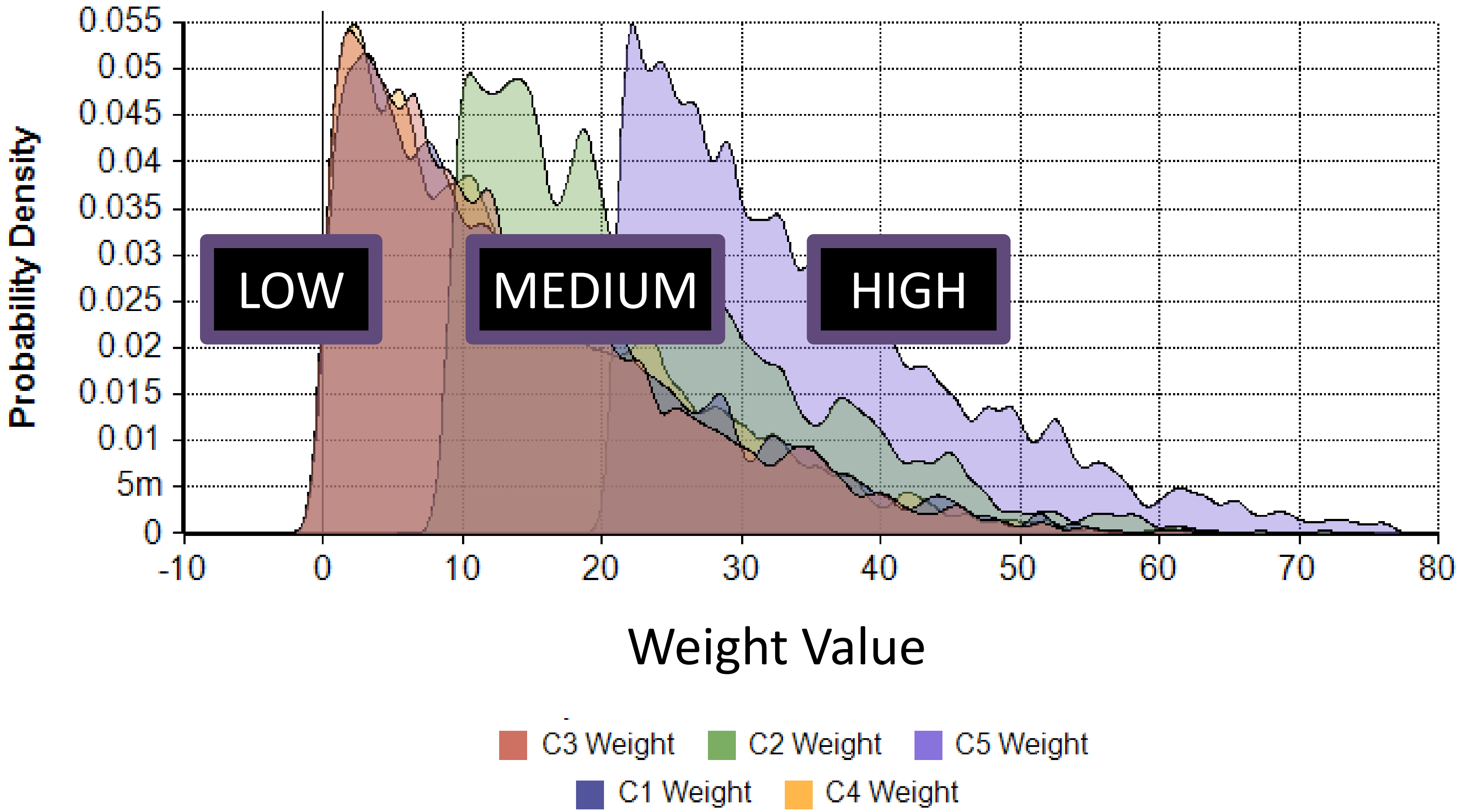


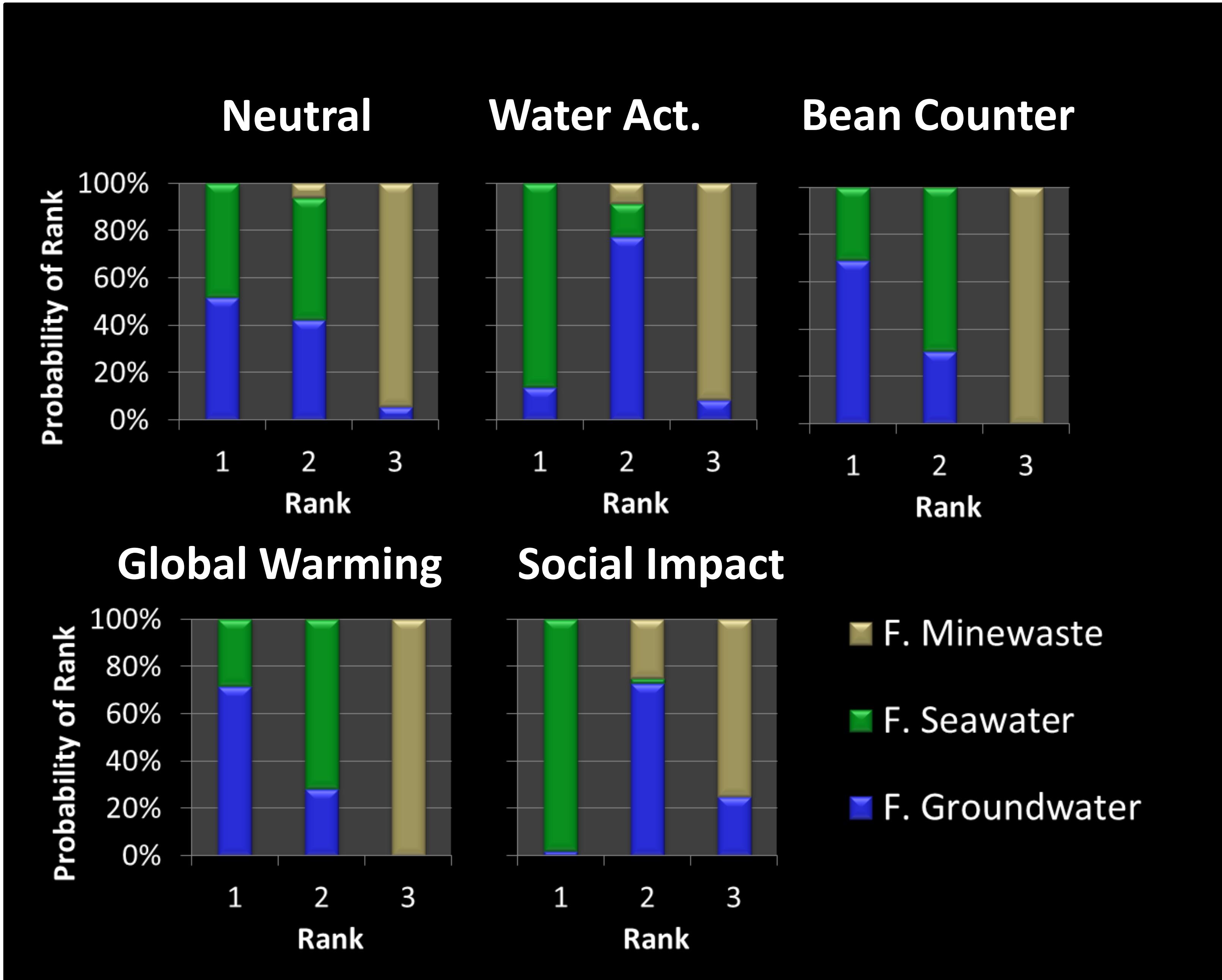
Meet the Decision Makers

1. Neutral
2. Bean Counter
3. Water Activist
4. Global Warming Activist
5. Social Impact focused

mediabistro.com

Stochastic Weights (w/ preferences)

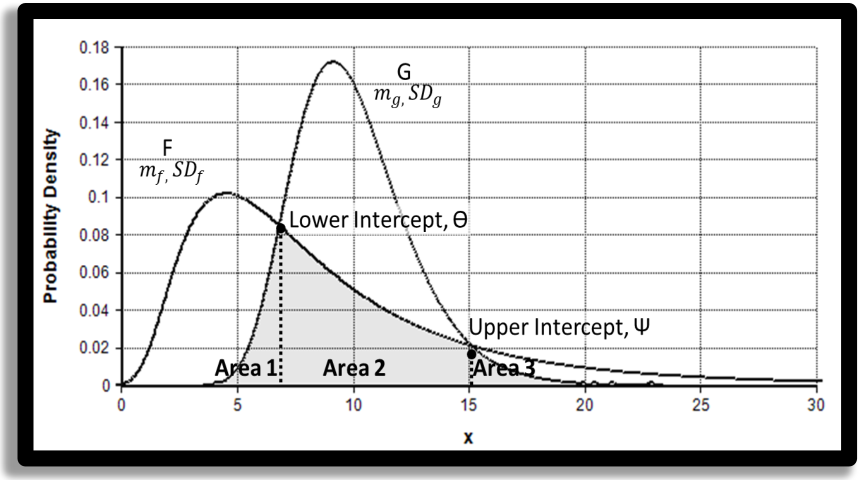




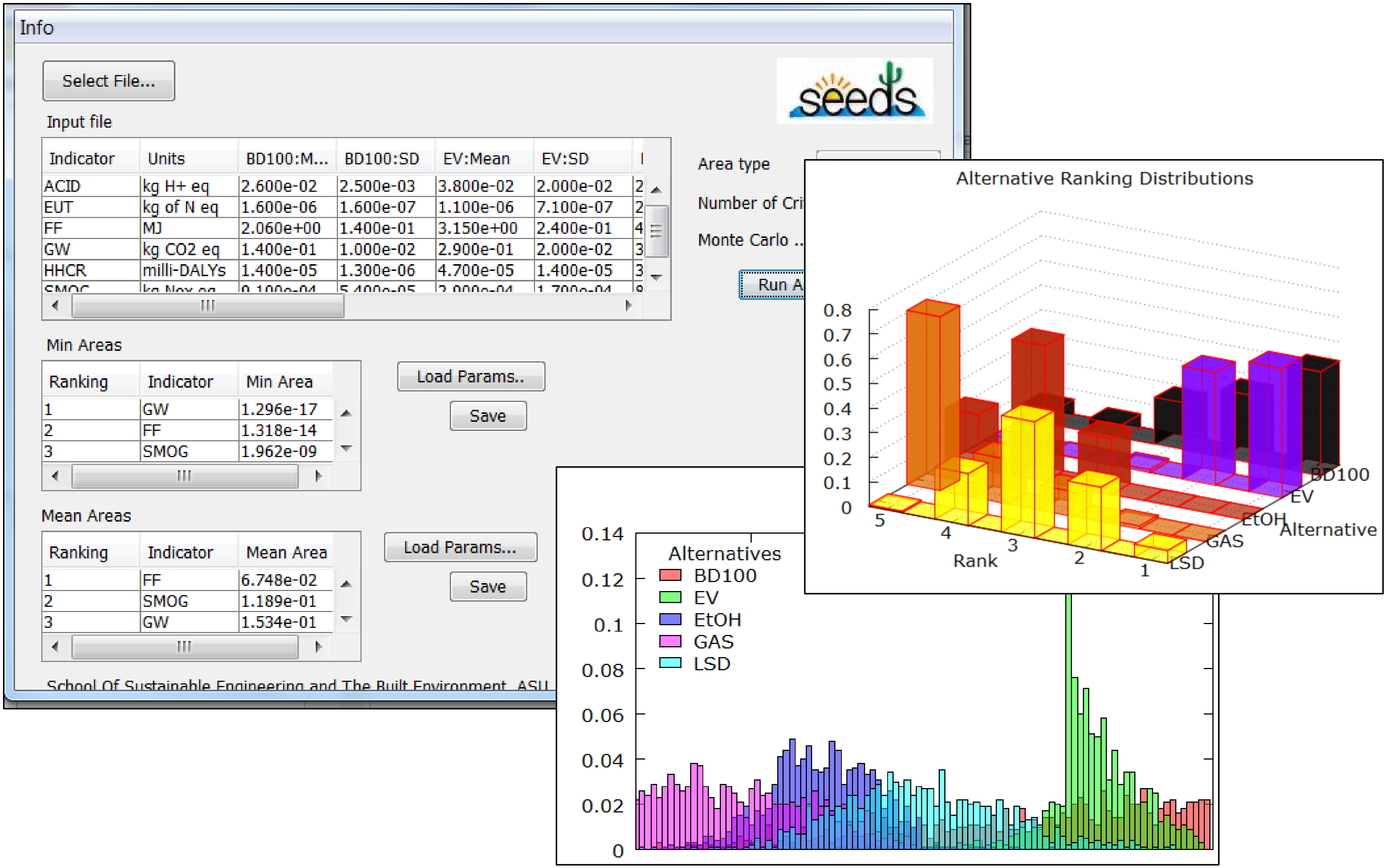
Prado-Lopez et al., 2013

Conclusions

- Interpretation of Comparative LCAs:
  - Tradeoffs (Relative)
  - Partially Compensatory
  - Performance Uncertainty
  - Weight Uncertainty



SMAA-LCA


Info
Select File...
Input file
Indicator | Units | BD100:M... | BD100:SD | EV:Mean | EV:SD
ACID | kg H+ eq | 2.600e-02 | 2.500e-03 | 3.800e-02 | 2.000e-02
EUT | kg of N eq | 1.600e-06 | 1.600e-07 | 1.100e-06 | 7.100e-07
FF | MJ | 2.060e+00 | 1.400e-01 | 3.150e+00 | 2.400e-01
GW | kg CO2 eq | 1.400e-01 | 1.000e-02 | 2.900e-01 | 2.000e-02
HHCR | milli-DALYs | 1.400e-05 | 1.300e-06 | 4.700e-05 | 1.400e-05
Area type
Number of Cri
Monte Carlo ..
Run A
Min Areas
Ranking | Indicator | Min Area
1 | GW | 1.296e-17
2 | FF | 1.318e-14
3 | SMOG | 1.962e-09
Load Params..
Save
Mean Areas
Ranking | Indicator | Mean Area
1 | FF | 6.748e-02
2 | SMOG | 1.189e-01
3 | GW | 1.534e-01
Load Params...
Save
School Of Sustainable Engineering and The Built Environment, ASU
Alternative Ranking Distributions
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
5
4
3
2
1
Rank
BD100
EV
EtOH
GAS
LSD
Alternative
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Alternatives
BD100
EV
EtOH
GAS
LSD

Thank You!

UIC INSTITUTE FOR ENVIRONMENTAL SCIENCE AND POLICY

UIC Department of Urban Planning and Policy
COLLEGE OF URBAN PLANNING & PUBLIC AFFAIRS

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Sustainable Energy & Environmental Decision Science