MILJØVURDERINGER PÅ FORURENEDE GRUNDE

TRIAD - Et lokalitets-specifikt beslutningsstøttesystem

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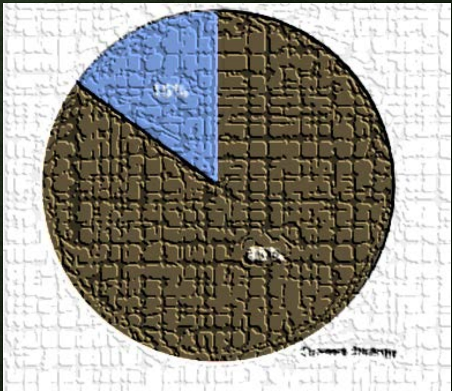
Miljøvurdering af forurenede grunde
Del II

JORD I HOVEDET IKKE AT BESKYTTE DET TERRESTRISKE MILJØ?

- Frugtbar jord er en vigtig og begrænset ressource
- En meget lang række af økosystemtjenester er knyttet til jord
- En altovervejende andel af liv på kloden er knyttet til terrestriske økosystemer
- Jord er det bærende element i det terrestriske økosystemer

Of the roughly 1.5 million known species of macroscopic organisms on earth, the modern ocean — despite its much larger area and volume — supports only about 15% of species, whereas terrestrial environments account for about 80% of species, and freshwater for the remaining 5% (Figure 1). Even when taking into account previously undetected biodiversity in all of the physical realms revealed through molecular techniques, these differences appear to be robust — certainly among multicellular organisms.

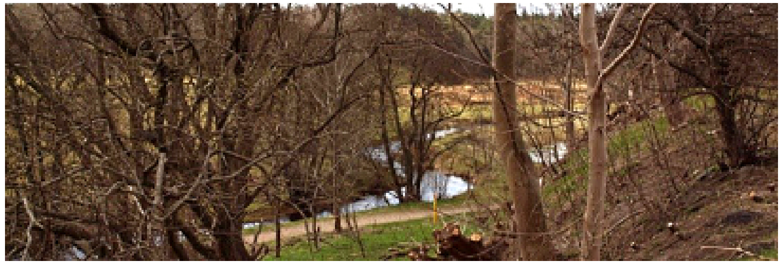


Grosberg et al 2012: https://doi.org/10.1016/j.cub.2012.09.050

FORURENET JORD –
MERE END BARE EN PUNKTKILDE

- Jordforureningsloven er ændret så miljøskader kan inddrages….bare ikke skader på jordmiljøet i sig selv.
- Indsatsområder:
  1. have skadelig virkning på grundvand,
  2. have skadelig virkning på overfladevand,
  3. have skadelig virkning på internationale naturbeskyttelsesområder eller
  4. have skadelig virkning på mennesker på et areal med bolig, børneinstitution eller offentlig legeplads.«.
- Et paradoks at vandrammedirektivet er det eneste lovmæssige redskab til at sikre jordmiljøet generelt
- Et europæisk jordrammedirektiv er (indtil videre) skrinlagt

Jordforurening i naturområder - Fakta



Ny lovgivning - og indsats efter 2019

Siden 1. januar 2014 har regionerne haft ansvar for jord- og grundvandsforureninger, der truer overfladevandet eller internationale naturbeskyttelsesområder.

Opgaven drejer sig i første omgang om at skabe overblik og identificere de relevante forureninger.

Den egentlige indsats fastlægges i forbindelse med vandmiljøplanerne, der skal vedtages i 2019.

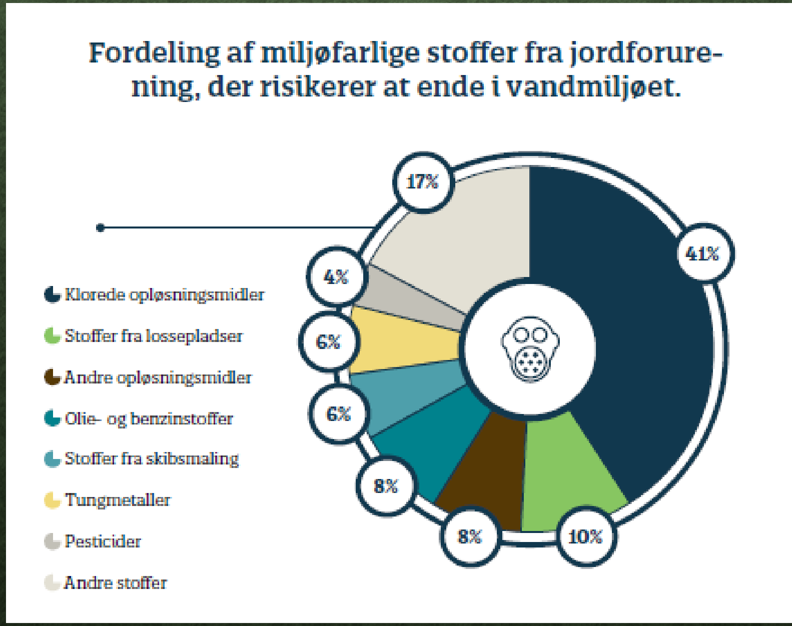
Grundlag

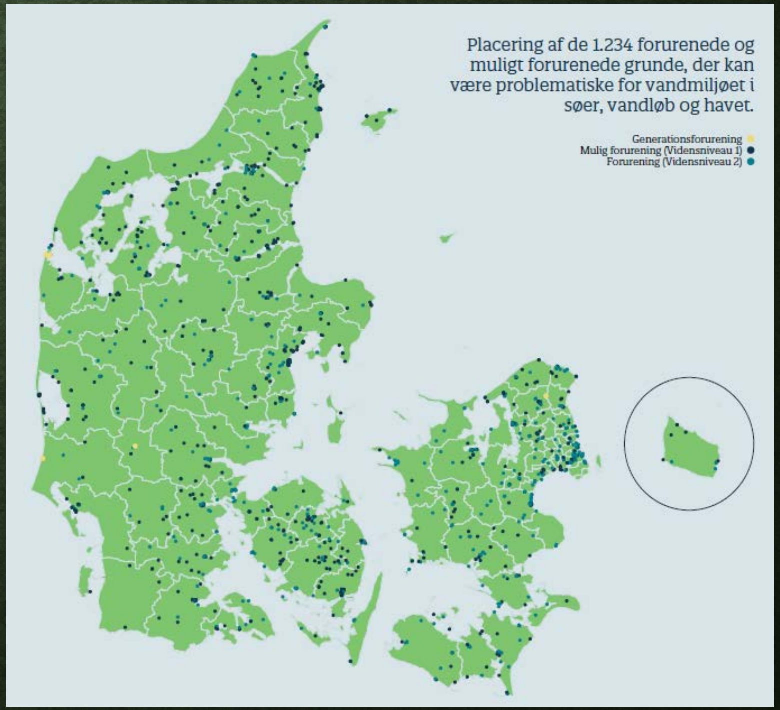
Ifølge EU's vandrammedirektiv skal det sikres, at vandmiljøet bevarer "god økologisk tilstand".

Målsætning og indsats for den enkelte recipient (naturen) fastlægges i vandmiljøplanerne fra Naturstyrelsen. En af kilderne til forurening af vandmiljøet er jordforureninger, der transporteres med grundvandet til overfladevandet.

FORURENEDE NATURAREALER

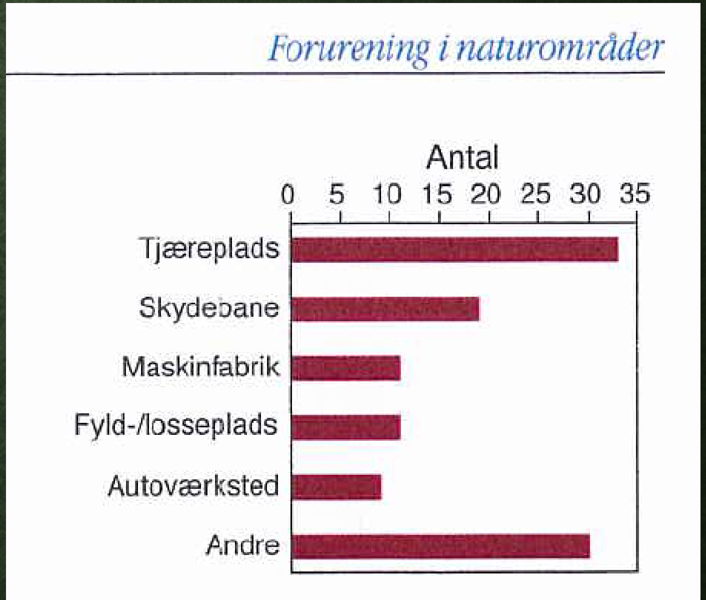
- Danske Regioner: 1.234 forureninger kan være problematiske for vandmiljøet. 36 af disse er store jordforureninger og 6 forureninger er generationsforureninger
- Men hvad med vore tørre naturarealer?





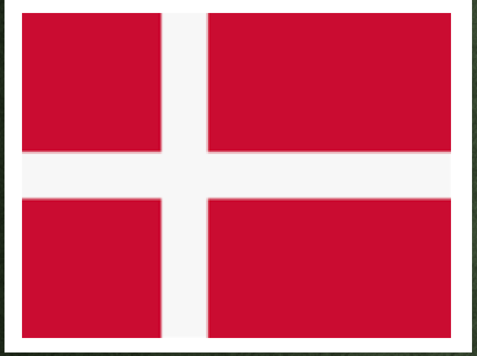
FORURENEDE §3 AREALER

- En mindre screening af forurenede grunde i Århus Amt viste at cirka 10% af områderne var beliggende i §3 områder
- §3 områder er bevaringsværdig natur.
- Harmonere det med jordforurening?
- Hvad nu hvis man ønsker at belyse miljørisici af forurenet jord?
- Hvilke metoder?
- Hvilke redskaber?
- Hvilke afværgemuligheder?



Figur 2. Opgørelse over hvilke type aktiviteter, der har været på de 117V1-kortlagte grunde i §3-områder.

JOHN JENSEN
NANNA SEIDELIN




TELEPHONE

GENERIC VS. SITE-SPECIFIC ERA

Risk of a new chemical introduced to the market:

Establishing environmental quality standards:

- PREDICTIVE RISK ASSESSMENT
- GENERIC, MODELS, PREDICTIONS

Risk of chemicals found at a contaminated site:

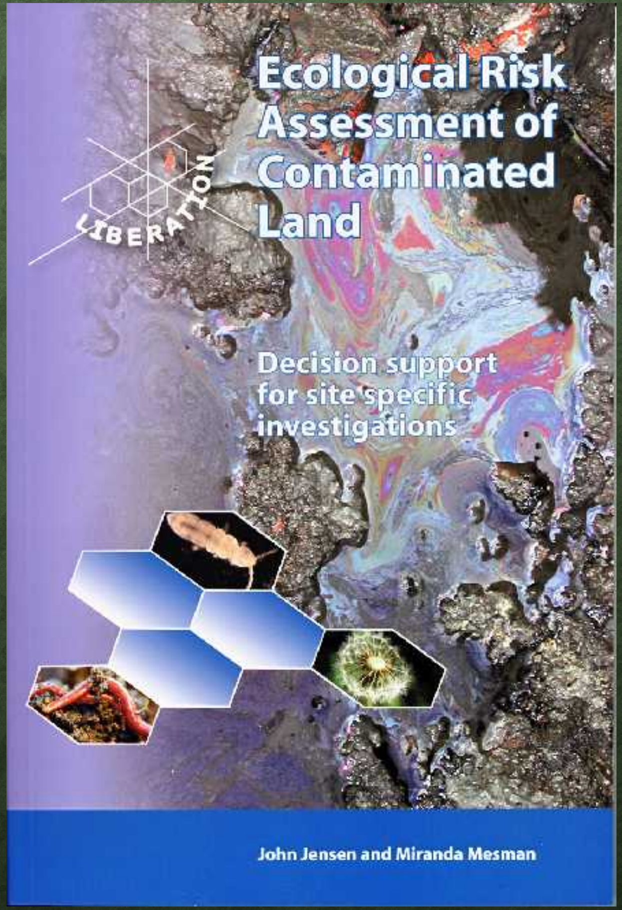
- DESCRIPTIVE RISK ASSESSMENT (IMPACT ASSESSMENT)
- SITE-SPECIFIC, INVESTIGATIONS, MEASUREMENTS

Decision Support System for Contaminated Sites

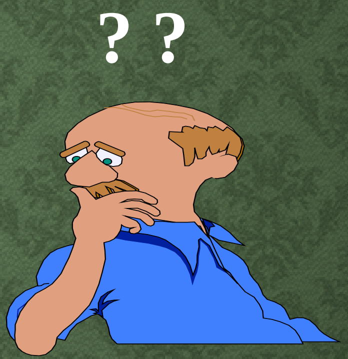
THE TRIAD

A decision support system for ecological risk assessment of contaminated soil.

The experience from the EU project ‘Liberation’



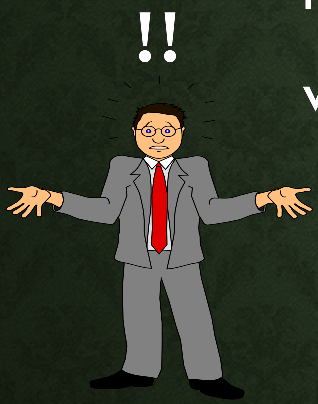
Ecological Risk Assessment



Ecosystems are not

more complex than

we think !



They are more complex than we <u>CAN</u> think

If the only tool you have is hammer then you tend to see all problems as a nail

after Egler 1977

<u>The</u> <u>risk</u> does not exist !

Complexicity of ERA

What to protect where?

Unicellular species – 1.100.000

Nematodes – 34.000

Enchytraeids - 520

Earthworms - 3

Springtails – 1.000

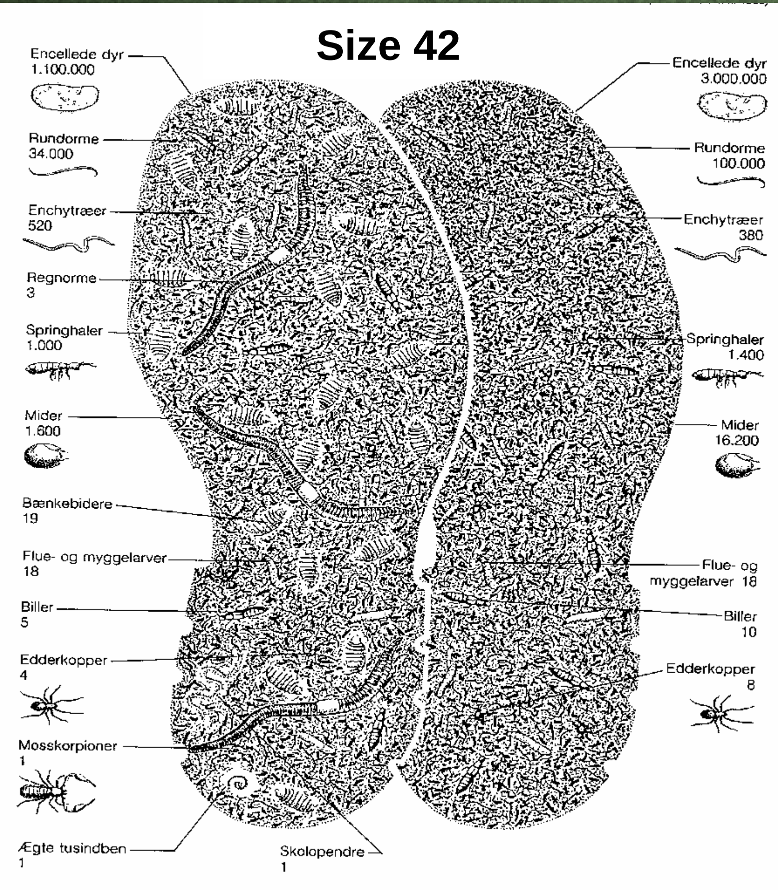
Mites – 1.600

Isopods - 19

Fly and mosquito larvae - 18
Beetles- 5
Spiders- 4

False scorpion- 4

Millipede - 1



Unicellular species – 3.000.0000

Nematodes – 100.000

Enchytraeids - 380

Earthworms - 0

Springtails – 1.400

Mites – 16.200

Isopods - 0

Fly and mosquito larvae - 18
Beetles- 10
Spiders- 8

False scorpion- 0

Millipede - 0

Centipede - 1

Centipede - 0

Line of evidence

Environmental Chemist: Exposure and bioavailability is the key issue; we should solve this

Ecotoxicologist: Measure toxicity! It is not necessary to measure the cocktail of chemicals.

Ecologist: Look for effects in the field, this is what really matters !

Line of evidence

Environmental Chemist: Exposure and bioavailability is the key issue; we should solve this

Ecotoxicologist: Measure toxicity! It is not necessary to measure the cocktail of chemicals.

Ecologist: Look for effects in the field, this is what really matters !

Combined effort from different diciplines is necessary by multiple weight of evidence

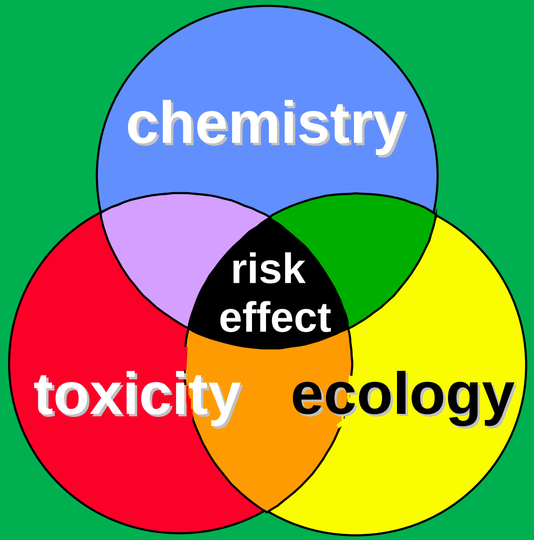
Decision Support System

The TRIAD Approach

Exposure assessment
Concentration of contaminants in environmental samples and biota
Comparison to benchmarks (EQS - literature toxicity data)

Toxicity assessment of soil
Tests with bioassays

Ecological observations 'in the field'
Community analysis
Eco-epidemiology



Three initial questions for ERA

- Is ERA relevant based on the information on land use and nature of contaminants, e.g. is there a Source-Pathway-Receptor linkage?
- Is the extent and level of contaminants sufficient to require site-specific ERA ?
- Are there any other confounding information ?

Defining land use

Examples of land use classes:

› Industry

› Urban/residential/parks

› Agricultural land

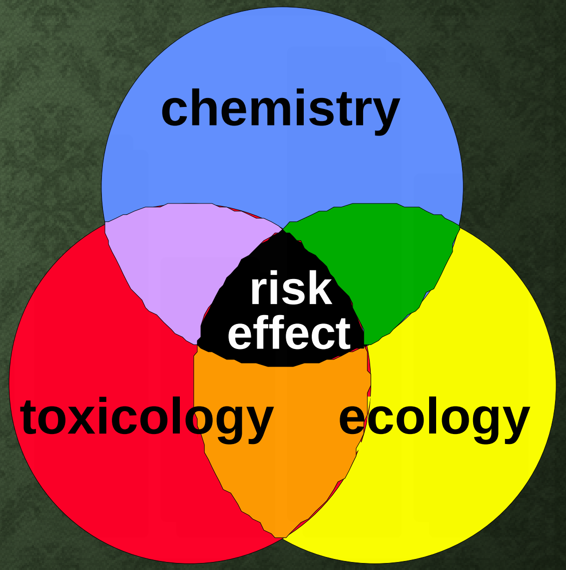
› Nature

Important to have defined quality objectives (EQS) and targets of protection (receptors) for each

The Triad – a brief introduction

Key elements:

- Lines of Evidence
- Tiers (test allocation)
- Scaling, weighting and integrating of results



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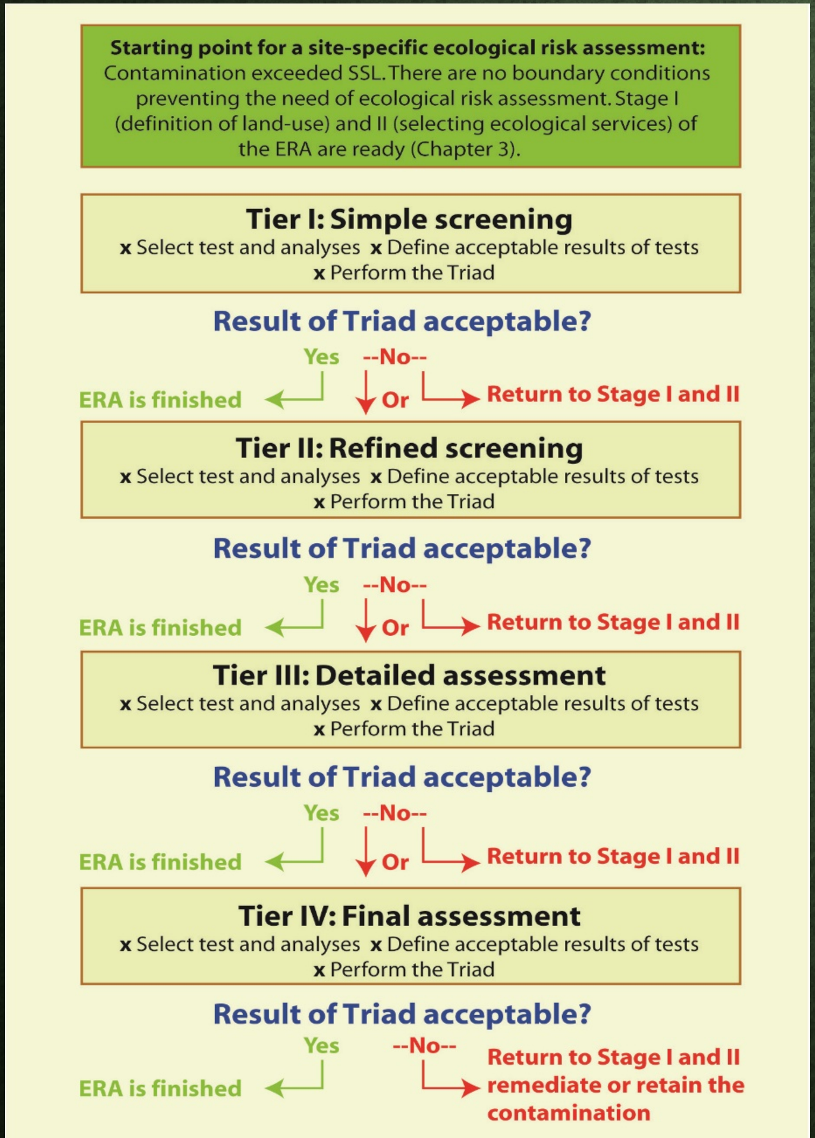
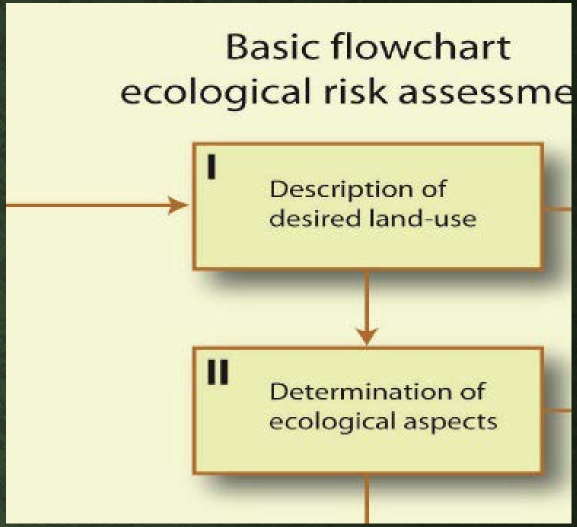
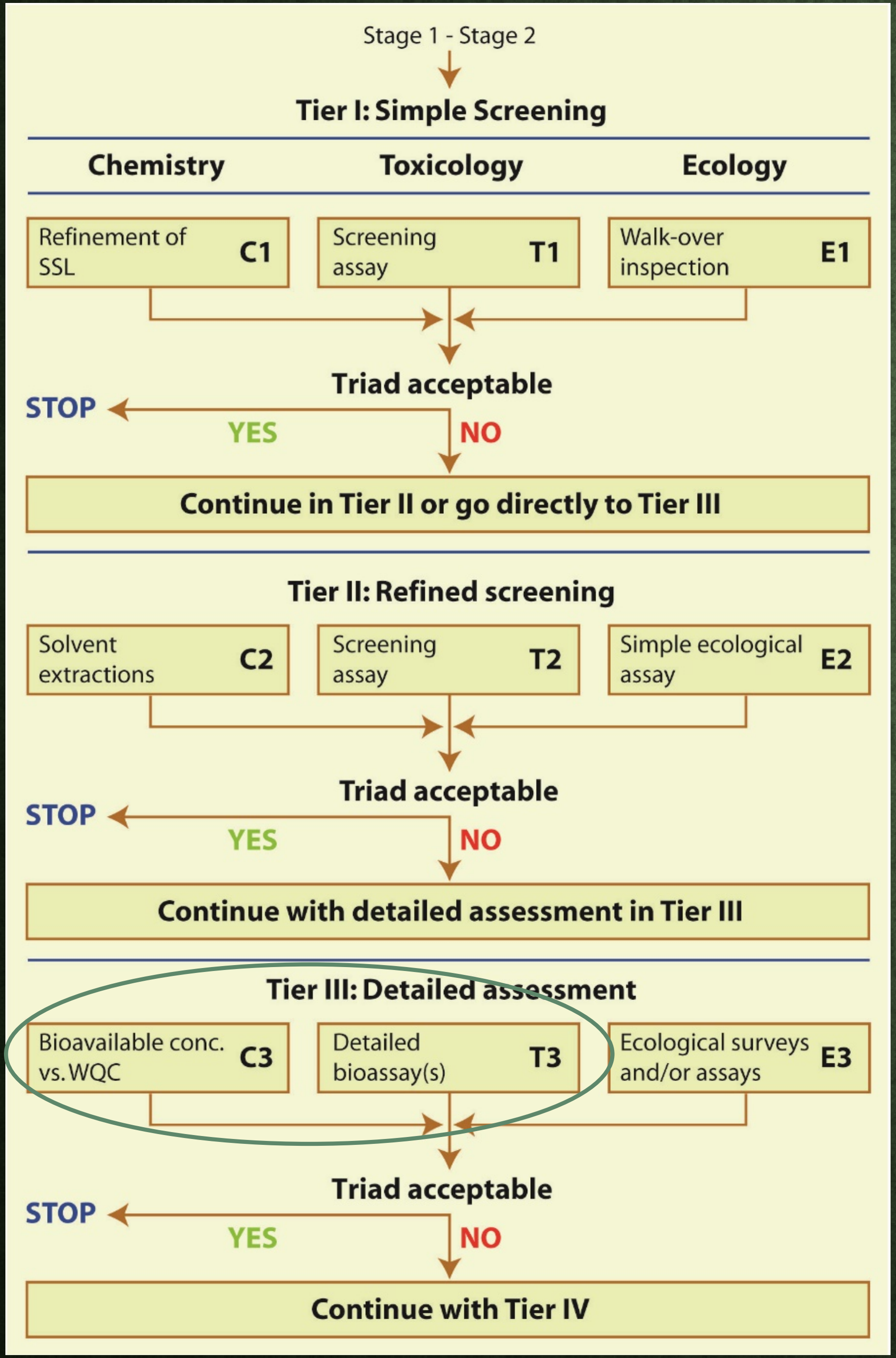


A tiered line of decisions



- Stepwise construction of investigations and test allocation
- Scaling, weighing and integration of resulsts

Examples of the allocation of tests in the various Tiers



Choice of tests - Ecotoxicology

Depending on land use, a suite of bioassays should be selected. A suite of bioassays in Tier 3 could for example be:

Nature:
Growth study with several herbal plant species, reproduction tests with several soil invertebrates and microbial activity measured as specific N- or C-mineralisation, e.g. potential ammonium oxidation.

Agricultural land-use:
Growth study with one or more crop species, earthworm reproduction test and microbial activity measured as specific N- or C-mineralisation, e.g. potential ammonium oxidation.

Industrial land-use:
Plant growth study with one common grass species and a general soil induced respiration (CO_2 production) test.

Choice of tests - Chemistry

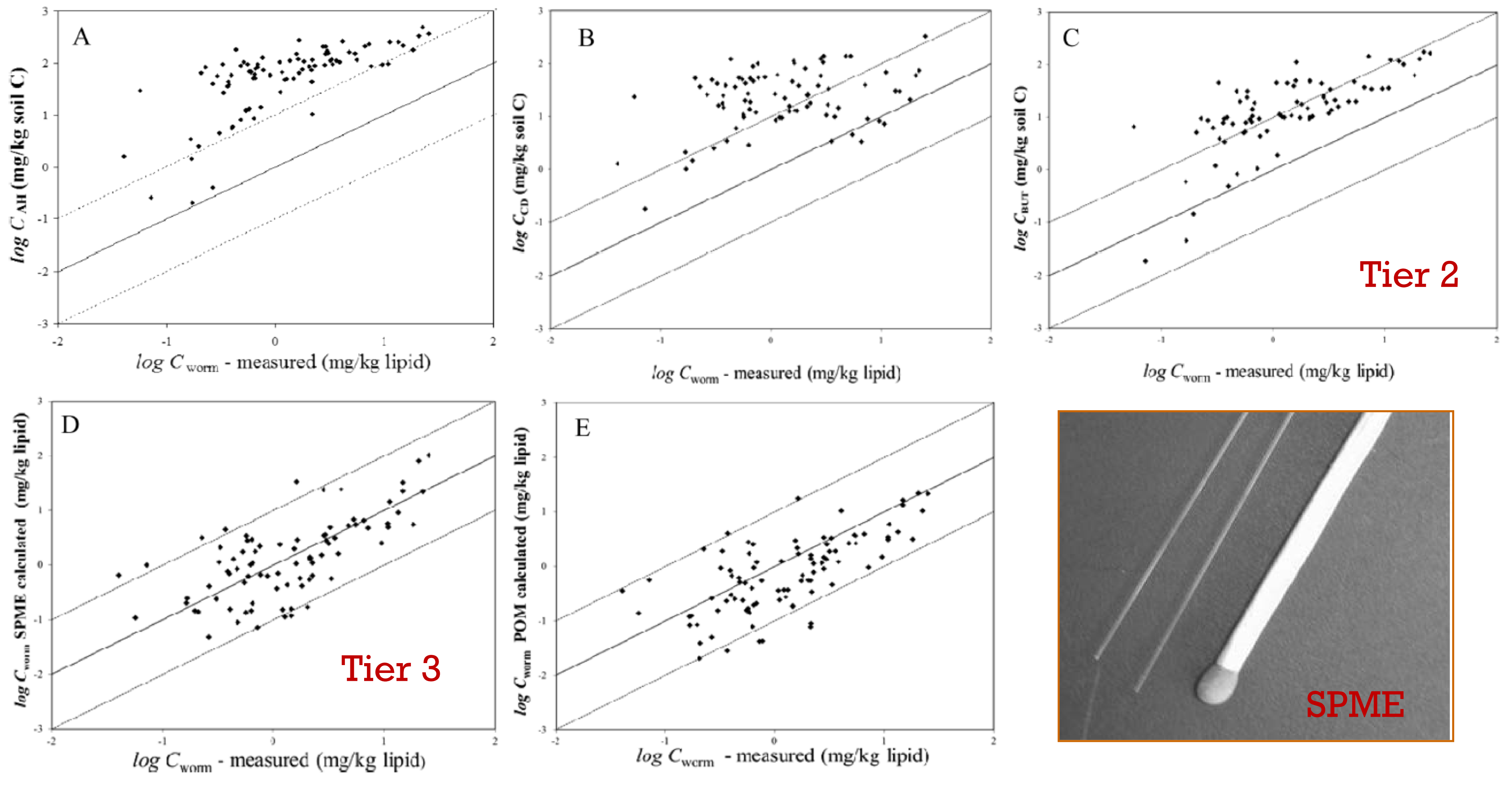
Depending on land use, a suite of bioassays should be selected. A bioavailability-mimicking chemical extraction in Tier 2-3 could for example be:

Tier 2: Butanol extraction

Tier 3: SPME extraction

CORRELATION WITH UPTAKE - EARTHWORM

acetone/hexane *cyclodextrin* *butanol*



SPME *SPE*

- Polymer coated fibers.
- Hydrophobic chemicals diffuse to coating
- Thermal desorption in GC or solvent desorption in HPLC

Correlation with Uptake – Plant Roots

acetone/hexane *cyclodextrin* *butanol*

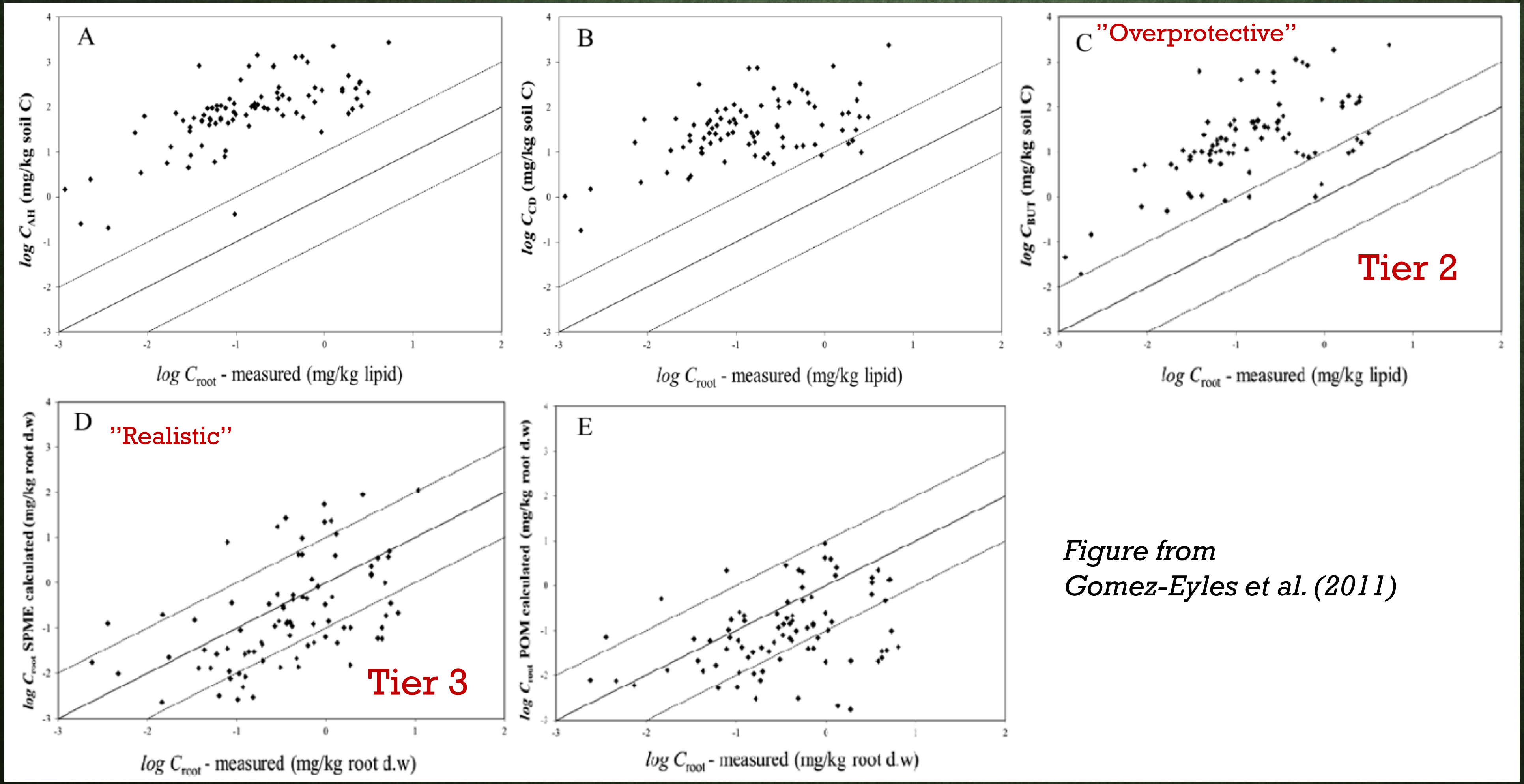


Figure from Gomez-Eyles et al. (2011)

SPME *SPE*

Scaling

- All data points have to be scaled between 0 and 1
- No guidance on scaling can be found in international guidelines
- May therefore need strong expert knowledge and pragmatisms

Text Box 1. Examples on how to scale the results from two types of toxicity tests.

Scaling. Example 1. Results in percentages.
This method can be used as default when the results from the test are expressed as percentages (%), e.g. mortality (negative effect) or survival (positive effect). Note: the results have to lie between 0 and 100%.

Scaling method 1A. Negative response in reference/control sample
Test Example: Algae light inhibition

Data:	Reference	Site A	Site B
Test results (%):	4.0	46	71

Step 1. Divide data by 100. R1=X /100

	Reference	Site A	Site B
Result (R1)	0.04	0.46	0.71

Step 2: Scale difference between X and reference. R2 = (X – Ref) / (1 – Ref)

	Reference	Site A	Site B
Result (R2)	0.0	0.44	0.70

Scaling method 1B. Positive response in reference/control sample
Test Example: Survival of earthworms

Data:	Reference	Site A	Site B
Test results (%):	98	40	10

Step 1. Subtract from 100 and then divide by 100. R1=(100-X)/100

	Reference	Site A	Site B
Result (R1)	0.02	0.60	0.90

Step 2. Scale difference between X and reference. R2 = (X – Ref) / (1 – Ref)

	Reference	Site A	Site B
Result (R2)	0.0	0.59	0.90

Chemical LoE.

Data (estimation of effect from)	Reference	Site A	Site B
Sum TP org. Chemicals	0.00	1.00	1.00
Sequential Supercritical Fluid Extraction	0.00	0.20	0.24
Leaching test in hand -packed columns	0.00	0.01	0.03
Sorption according to SPME measurements	0.00	0.00	0.56
Concentration in plant shoots (mg/kg)	0.00	0.24	0.68

Step 1. Calculate log to (1-scaled result). R1 = log(1-X)

	Reference	Site A	Site B
Sum TP org. Chemicals	0.00	-3.00	-3.00
Sequential Supercritical Fluid Extraction	0.00	-0.10	-0.12
Leaching test in hand -packed columns	0.00	0.00	-0.01
Sorption according to SPME measurements	0.00	0.00	-0.36
Concentration in plant shoots (mg/kg)	0.00	-0.12	-0.50

Step 2. Average all log values. R2= Average (X1…X*n*)

	Reference	Site A	Site B
Result (R2)	0.00	-0.64	-0.80

Step 3. Transform log values into values. R3=1-(10^X)

	Reference	Site A	Site B
Result (R3)	**0.00**	**0.77**	**0.84**

Integrated risk.

	Reference	Site A	Site B
LoE – Chemistry:	0.00	0.77	0.84
LoE – Toxicology:	0.00	0.23	0.34
LoE - Ecology:	0.00	0.21	0.29

Step 1. Calculate log to (1-scaled result). R1 = log(1-X)

	Reference	Site A	Site B
LoE – Chemistry:	0.00	-0.64	-0.80
LoE – Toxicology:	0.00	-0.11	-0.18
LoE – Ecology:	0.00	-0.10	-0.15

Step 2. Average all log-values to one integrated log value. R2 = Average ($X_1 \ldots X_n$)

	Reference	Site A	Site B
Result (R2)	0.00	-0.29	-0.38

Step 3. Transform log-values into integrated risk (IR) values. R3 = 1-(10^R2)

	Reference	Site A	Site B
Result (R3 = Integrated Risk)	**0.00**	**0.48**	**0.58**

Step 4. Calculate standard deviation (Std) of the integrated results for each site, i.e. three LoE

	Reference	Site A	Site B
Result (R4 = Std)	**0.00**	**0.55**	**0.53**

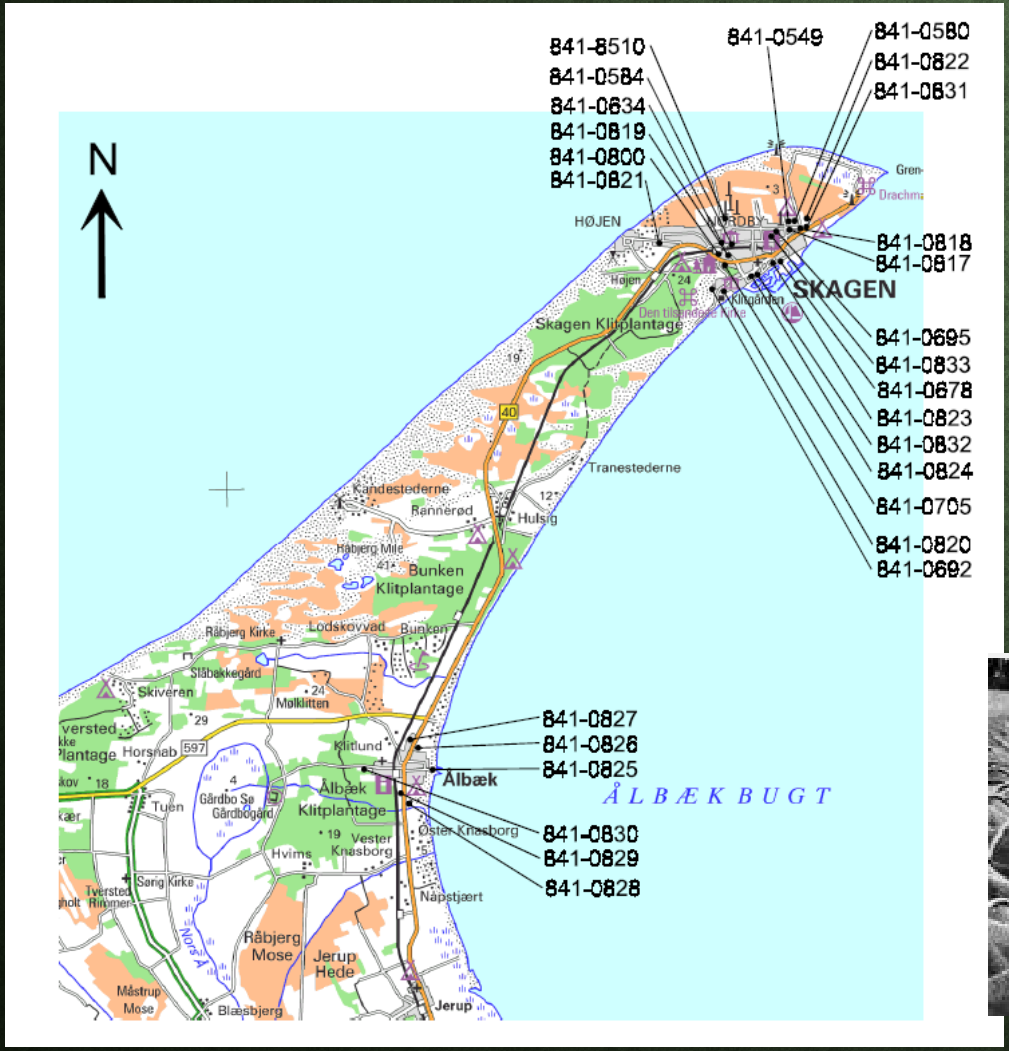
Decision Table (an example)

Table 4.1 Example how to interpret the outcome of the risk analysis in the Triad. It is highly recommended that stakeholders produce a similar table before the start of the Triad process. "Not acceptable" land-use does not necessarily have to imply remediation or soil management, but could also lead to more investigations. N = nature, A = agricultural, R = residential, I = industrial land-use.

Deviation (D)	Integrated Risk (IR)	Conclusion (land-uses)	
		Acceptable	Not Acceptable
D < 0.4 *	0.00 < IR < 0.25*	N, A, R, I	-
	0.26* < IR < 0.50*	A, R, I	N, A (with targets of concern)
	0.51* < IR < 0.75*	I, (R)	N, A, R (with "green" functions)
	0.76* < IR < 1.00*	I (with sealed soils)	N, A, R, I (with "green" functions)
D > 0.4* further studies or alternatively:	0.00 < IR < 0.25*	A, R, I	N, A (targets of concern)
	0.26* < IR < 0.50*	I, (R)	N, A, R (with "green" functions)
	0.51* < IR < 1.00*	I (with sealed soils)	N, A, R, I (green zones)

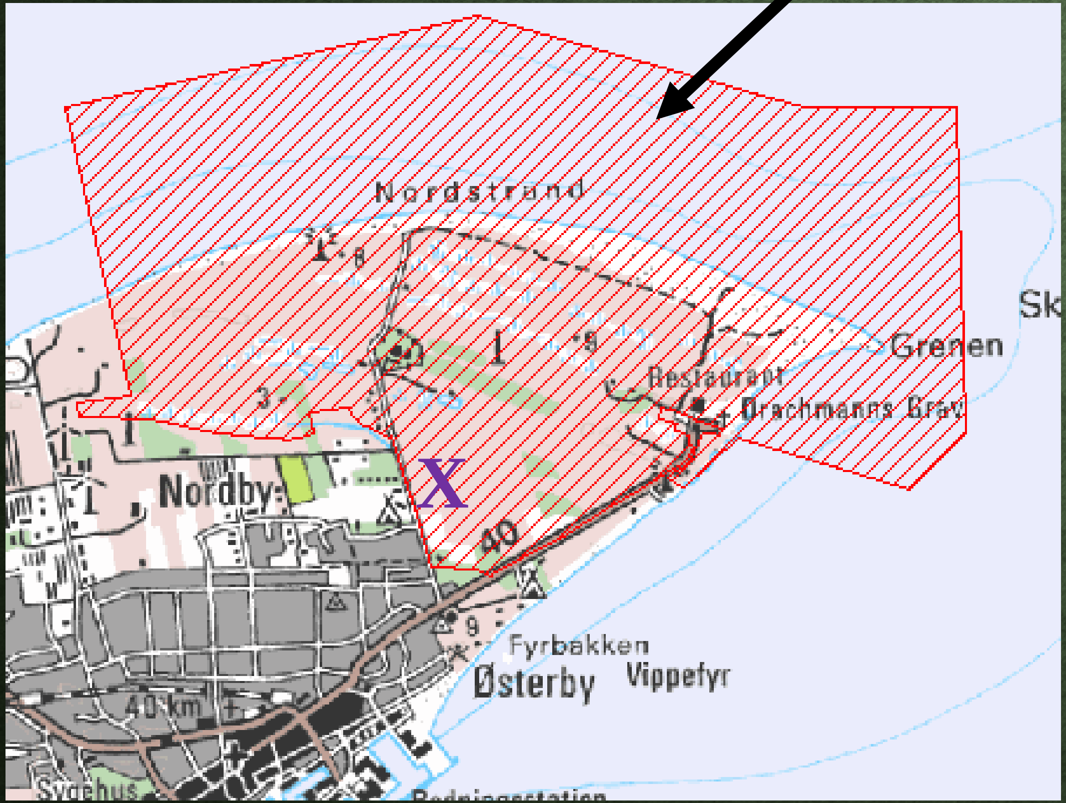
Criteria should in principle be agreed upon from case-2-case

CASE STUDY – TAR AND FISHING NETS



Case study: Skagen

Natura 2000 område



Case study: Skagen

Case study Skagen

Tier 1		
Chemistry	**Skagen M**	**Skagen H**
Sum TP soil (C1)	0.94	1.00
Toxicology		
Microtox solid phase (T1)	0.05	0.05
Ecology		
Plant community (E3)	0.17	0.34
Risk number	**0.64**	**0.91**

Tier 2 + 3

Chemistry	Skagen M	Skagen H
TP soil (C1)	0.94	1.00
TP pore water (C3)	0.06	0.66
Risk number	0.76	0.98
Toxicology		
Microtox (T1)	0.05	0.05
Ostracod mortality (T1)	0.14	0.86
Springtail test (T3)	0.18	0.37
Daphnia survival (T3)	0.43	0.43
Risk number	0.21	0.53
Ecology		
Microarthropods (E3)	0.13	0.30
Plant community (E3)	0.17	0.34
Biolog (CLPP) (E3)	0.19	0.18
Risk number	0.16	0.28
Final assessment		
Risk - Chemistry	0.76	0.98
Risk - Toxicology	0.21	0.53
Risk - Ecology	0.16	0.28
Integrated risk number	0.46	0.82
Deviation	0.58	0.62

No weighing of data

	Skagen M	Skagen H
IR	0.46	0.82
Deviation	0.58	0.62

Risk number (Tier 1) 0.64 0.91

Deviation (D)	Integrated Risk (IR)	Conclusion (land uses)	
		Acceptable	Not Acceptable
D < 0.4	0 < IR < 0.25	N, A, R, I	-
	0.25 < IR < 0.50	A, R, I	N, A (with targets of concern)
	0.5 < IR < 0.75	I, (R)	N, A, R (with “green” functions)
	0.75 < IR < 1.0	I (sealed)	N, A, R, I (with “green” functions)
D > 0.4 further studies or alternative:	0 < IR < 0.25	A, R, I	N, A (targets of concern)
	0.25 < IR < 0.50	I, (R)	N, A, R (with “green” functions)
	0.5 < IR < 1	I (sealed)	N, A, R, I (green zones)

- More and better studies may be required
- Differentiated weighing a possibility
- Tar affects flora and fauna locally
- The impact is larger in the hot spot areas
- The contamination is unlikely to migrate
- Natural attenuation could be a suitable remediation option combined with dig and dump of the hot spots

KONKLUSIONER

- Miljøvurdering af forurenede grunde bør altid være lokal-specifik
- Første skridt bør altid være en simpel sammenligning med generiske JKK
- Informationer fra flere discipliner bør inddrages
- TRIAD er et stærkt tværfagligt beslutningsstøttesystem
- Alle interessenter (stakeholders) bør være enige om mål og metoder, samt vægtning af resultater inden planlægning og udførelse af en miljøvurdering