A Strategic Research Agenda for Radioecology

Thomas Hinton

Paris; 19 June 2012

In June 2009, the Director Generals of **EIGHT** European organizations signed a Memorandum of Understanding to address emerging problems in radioecology

Strål säkerhets myndigheten
Swedish Radiation Safety Authority

Statens strålevern
Norwegian Radiation Protection Authority

NATURAL ENVIRONMENT RESEARCH COUNCIL

IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

STUK

Bundesamt für Strahlenschutz

SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

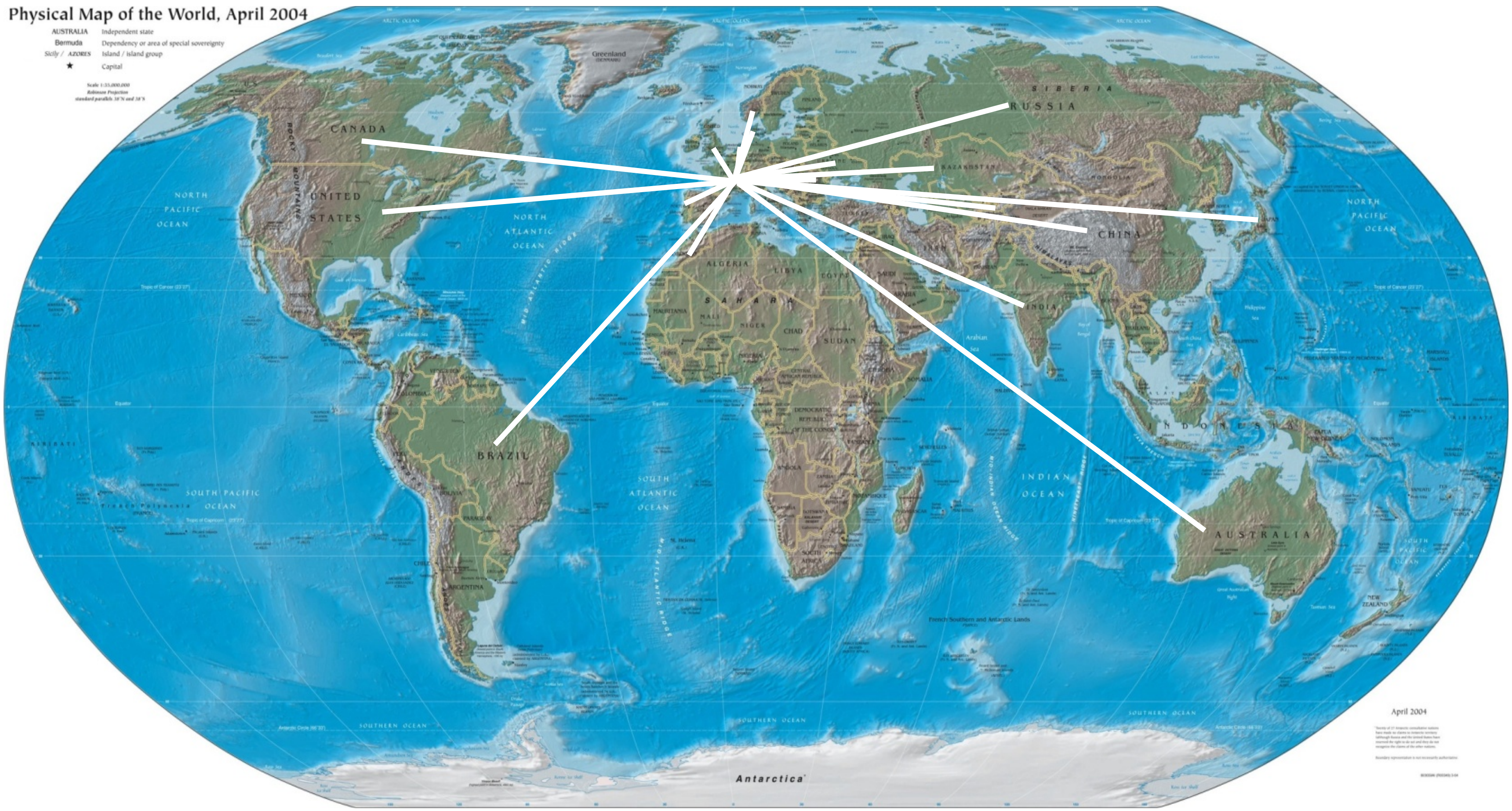
Memorandum of Understanding

EUROPEAN RADIOECOLOGY ALLIANCE

- will address **scientific and educational challenges** relative to the **impact of radioactive substances on humans and the environment**

- will **integrate** portions of **their respective research efforts** into a **trans-national programme**

The ALLIANCE intends to be international, and many organizations have expressed interest in joining



EUROPEAN RADIOECOLOGY ALLIANCE

SEVENTH FRAMEWORK PROGRAMME

In February 2011, ALLIANCE members, with **Stockholm University** and the **Norwegian University of Life Sciences**, acquired funding from the European Commission to establish a

NETWORK of EXCELLENCE in Radioecology

A major task within STAR is to develop a Strategic Research Agenda for radioecology

Alliance Members:

- IRSN (France)
- NERC (UK)
- CIEMAT (Spain)
- SCK-CEN (Belgium)
- NRPA (Norway)
- STUK (Finland)
- BfS (Germany)
- SSM (Sweden)

STAR

STRATEGY FOR ALLIED RADIOECOLOGY

The **Strategic Research Agenda** is a suggested prioritisation of research topics in radioecology, with a goal of improving research efficiency and more rapidly advancing the science.

It responds to the question:

"*What topics, if critically addressed over the next 20 years, would significantly advance radioecology*?"

The SRA is a VISION, in which the developers were asked to think creatively and without bounds as they imagine the results that could most shape the future of radioecology and benefit stakeholders...

Development of the Strategic Research Agenda

Radioactive contamination: State of the science and its application to predictive models. 1999. Whicker et al. *Environmental Pollution*

Strong inference and radioecology. 2000. Hinton. *Journal Environ. Radioactivity*

Protection of the environment in the 21st century: Radiation protection of the biosphere including human kind. Statement of the International Union of Radioecology. 2003. Brechignac et al. *Journal Environmental Radioactivity*

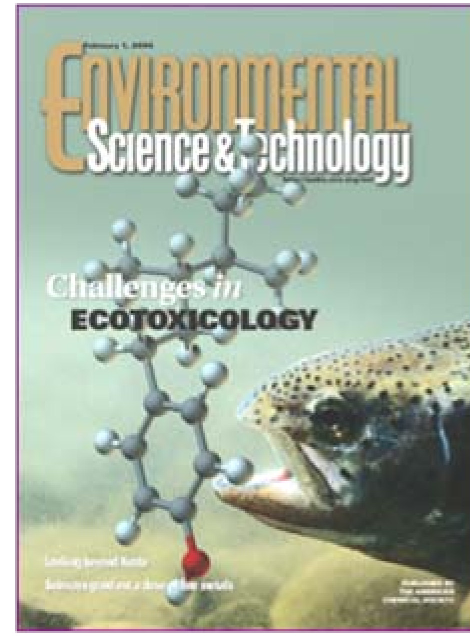
Assessing ecological effects of radionuclides: Data gaps and extrapolation issues. 2004. Garnier-Laplace et al. *J. Rad. Protection*

Applying radioecology in a world of multiple contaminants. 2005. Shaw. *Journal Environmental Radioactivity*

Radioecology: History and state-of-the-art at the beginning of the 21st century. 2006. Alexakhin R. *Radiation Risk Estimates, Normal and Emergency Situations*.

Scientific Issues and Emerging Challenges for Radiological Protection. 2007. Organisation for Economic Cooperation and Development. Nuclear Energy Agency, *Report of the Expert Group on the Implications of Radiological Protection Science.*

Development of the Strategic Research Agenda



Does ecotoxicology inform ecological risk assessment? 2003. Calow and Forbes. *Environmental Science & Technology*

Challenges in ecotoxicology. 2004. Eggen et al. *Environmental Science & Technology*

Integrating environment protection, a new challenge: Strategy of the International Union of Radioecology. Brechignac et al. 2008. *Radioprotection*

Networking–a way for maintaining and enhancing radioecological competences in Europe. FUTURAE. 2008. *Deliverable 4*

Radioecology, radiobiology, and radiological protection: frameworks and fractures. Pentreath. 2009. *Journal Environ. Radioactivity*

Challenges in radioecology. Salbu. 2009. *Journal Environ. Radioactivity*

Radioecology for tomorrow: An international challenge, both scientific and operational. Repussard. 2011. *International Conference on Radioecology and Environmental Radioactivity*

Towards a renewed research agenda in ecotoxicology. Artigas et al. 2012. *Environ. Pollution*

The SRA was formed by considering:

(i) recent changes in policy

(ii) new scientific advancements

(iii) improving credibility with stakeholders

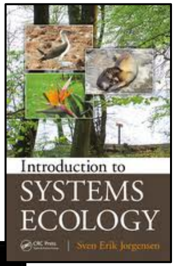
(iv) science deficiencies

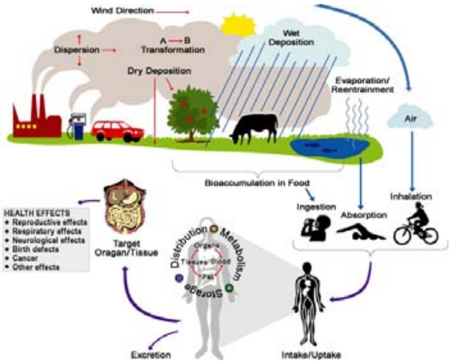
(v) integration issues

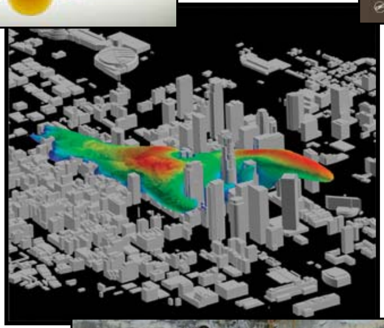
(vi) potential future risks

(vii) early lessons from the Fukushima disaster

Contaminant
Mixtures







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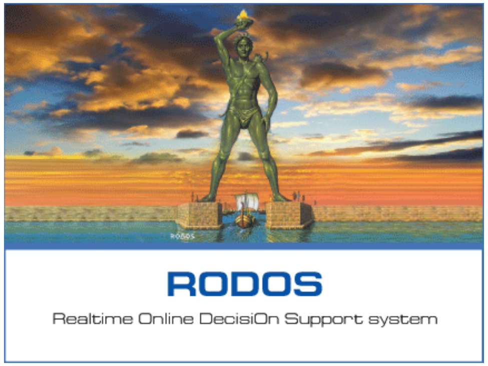
Development of the Strategic Research Agenda

MELODI

DoReMi
Integrating Low Dose Research

NERIS-TP

...the portal of the European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery



PROTECT
Knowledge Exchange
Sharing Knowledge

STAR

Interests of ALLIANCE member organisations…

Statens strålevern
Norwegian Radiation Protection Authority

Bundesamt für Strahlenschutz

STUK

NATURAL
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RESEARCH COUNCIL

Strål
säkerhets
myndigheten
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Belgian Nuclear Research Centre
Research towards a sustainable option

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STRATEGIC RESEARCH AGENDA

The SRA identifies three important **Scientific Challenges** that radioecology needs to address

Each Scientific Challenge includes a **Vision Statement** of what should be accomplished over the next 20 years in that area of radioecology

Each Scientific Challenge includes **Key Research Lines** required to accomplish the vision

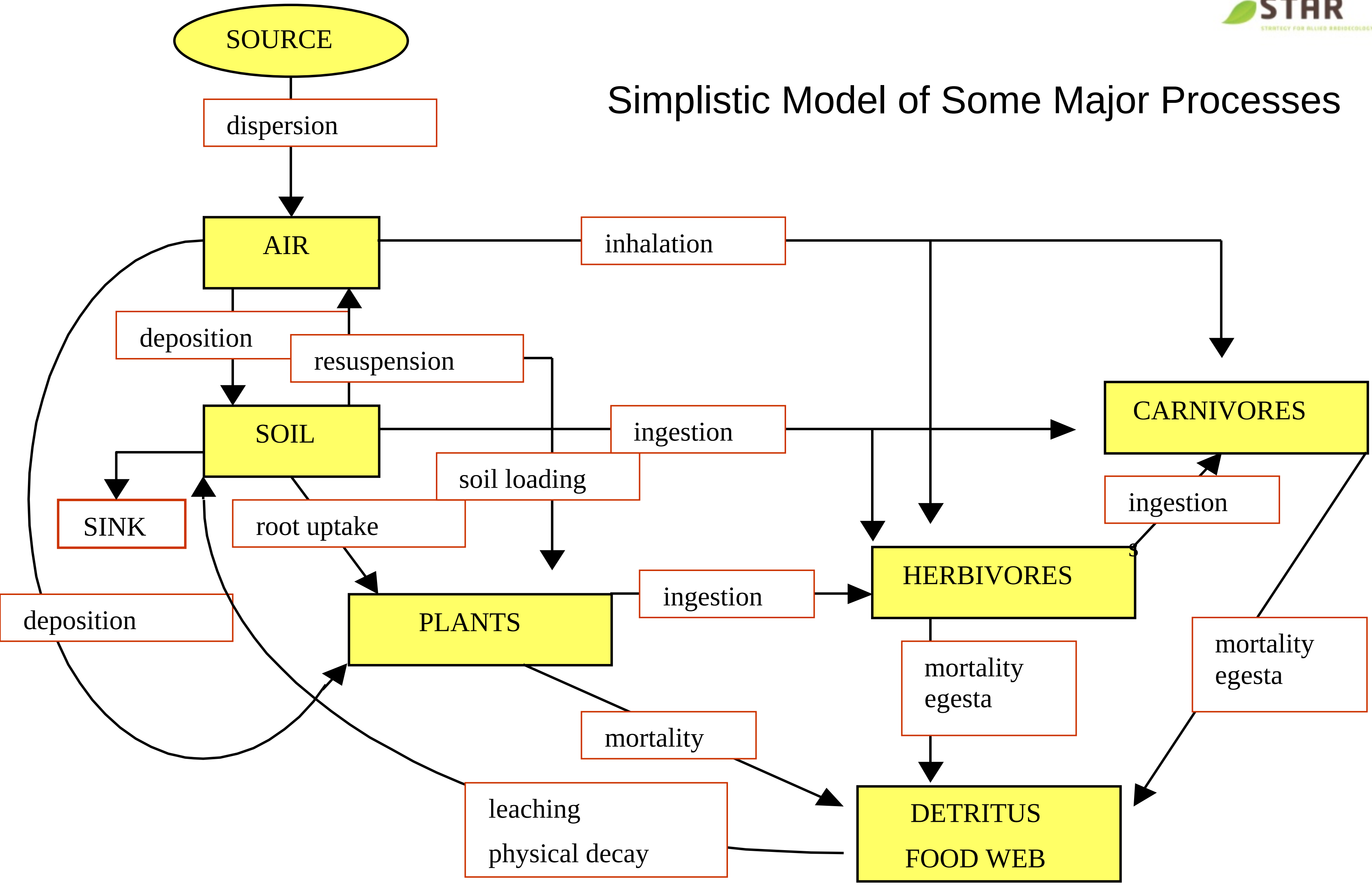
(a total of 15 research lines were prioritised within the SRA)

CHALLENGE ONE

To Predict Human and Wildlife Exposure More Robustly by Quantifying the Key Processes that Most Influence Radionuclide Transfers

Our strategic vision is that over the next 20 years radioecology will have achieved a thorough mechanistic conceptualisation of radionuclide transfer processes within major ecosystems (terrestrial, aquatic, urban), and be able to accurately predict exposures to humans and wildlife by incorporating a more profound understanding of environmental processes.

Simplistic Model of Some Major Processes



Concentration Ratio

$$CR = \frac{Bq\,kg^{-1}\,plant}{Bq\,kg^{-1}\,soil}$$

Modelers appreciate the simplicity of the *CR* :

it allows the contaminant concentration in a plant to be estimated merely by multiplying the soil concentration by a *CR*.

CR for ^{137}Cs can easily span three orders of magnitude, even for individual soil-crop combinations.

Table — Recommended C_r for radiocesium by crop and soil type.

Crop	Soil Type	Concentration Ratio	Lower 95% CI	Upper 95% CI
Cereals	Sand	0.021	0.00170	0.25
	Loam	0.014	0.00045	0.42
	Clay	0.011	0.00057	0.21
	Organic	0.043	0.00380	0.49
Tubers	Sand	0.110	0.0140	0.89
	Loam	0.029	0.0029	0.28
	Clay	0.029	0.0034	0.25
	Organic	0.055	0.0060	0.51

Regression analysis of Cs-137 uptake by plants as a function of numerous soil parameters

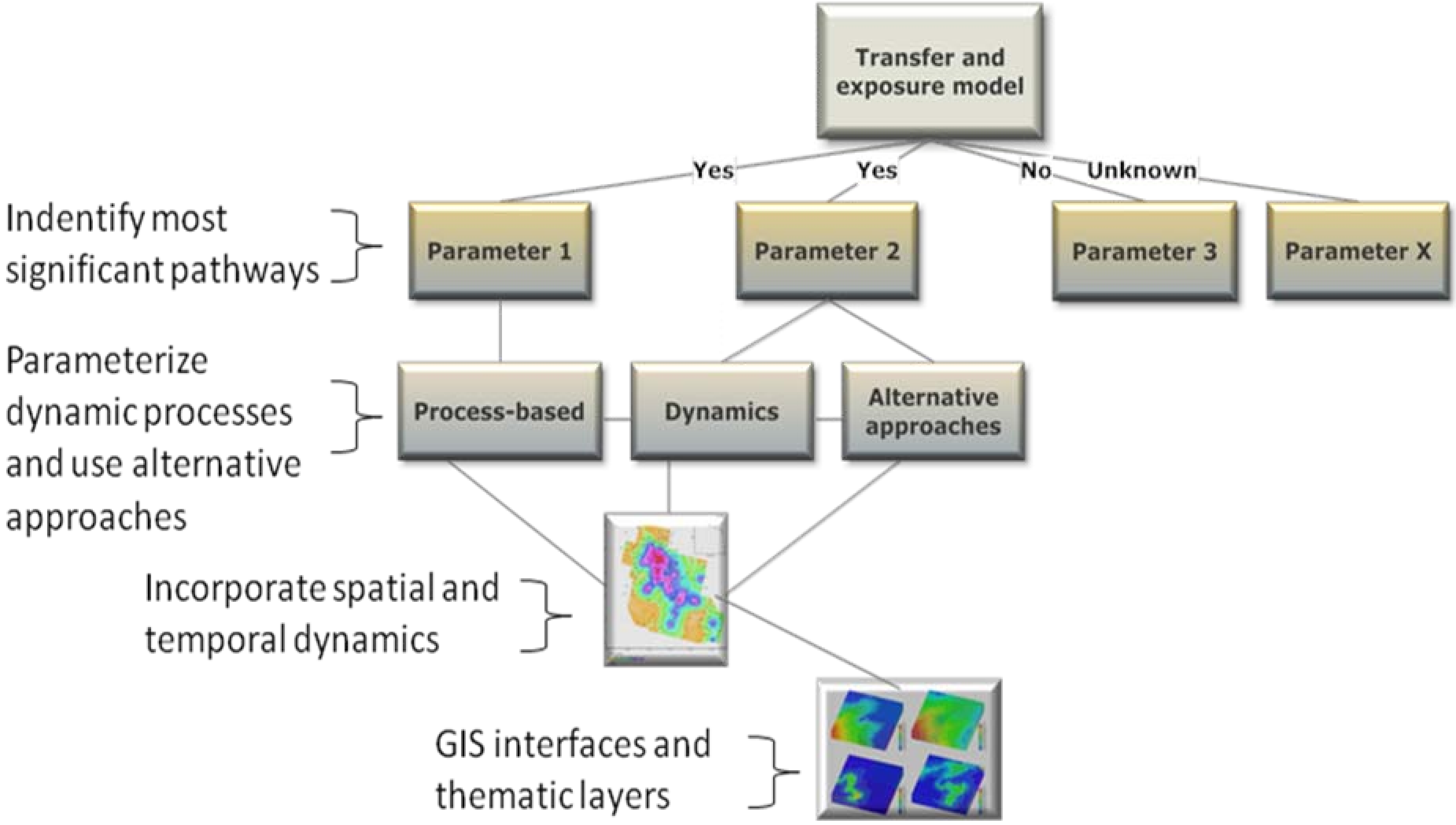
plant ^{137}Cs = 0.39 (soil ^{137}Cs) + 0.44 (Na) – 0.28 (pH) – 0.41 (K)

43% of the variation in ^{137}Cs plant concentrations was explained by the soil parameters examined

Our ability to predict contaminant concentrations in plants is moderate, at best, even after 50 years of data collection!

CHALLENGE ONE

To Predict Human and Wildlife Exposure More Robustly by Quantifying the Key Processes that Most Influence Radionuclide Transfers



CHALLENGE TWO

To Determine Environmental Effects under the Realistic Conditions that Organisms are Exposed

Our strategic vision is that over the next 20 years radioecology will have gained a thorough mechanistic understanding of the processes that induce radiation effects at different levels of biological organisation, including consequences on ecosystem integrity, and be able to accurately predict effects under the realistic conditions in which organisms are actually exposed.

Most Contaminant Research Is Not Directly Relevant to Responses in Nature

Data Plentiful; but Least Relevant	***Data Scarce; but Most Relevant***
Individual response	Population response
Mortality	Reproduction
Acute exposure	Chronic exposure
External gamma	Multiple exposure routes
Laboratory	Field
Short-term	Long-term
Direct effects	Indirect effects
Single contaminants	Multiple stressors

Extrapolating effects from the molecular level to the cellular level, or from individuals to groups of many individuals and species, is a major objective in ecotoxicology that has yet to be achieved.

Calow & Forbes

CHALLENGE TWO

To Determine Environmental Effects under the Realistic Conditions that Organisms are Actually Exposed

Different Levels of Biological Complexity

Sub-organism
Individual
Population
Community
Ecosystem

RESULTS

Process Understanding;
Population and ecosystem effects models;
More robust assessment factors and screening values

Results in:

VISION & STRATEGY

Realistic Exposure Conditions

Chronic versus acute exposure
Low versus high LET
Internal versus external exposure
Indirect effects
Environmental factors and multiple stressors

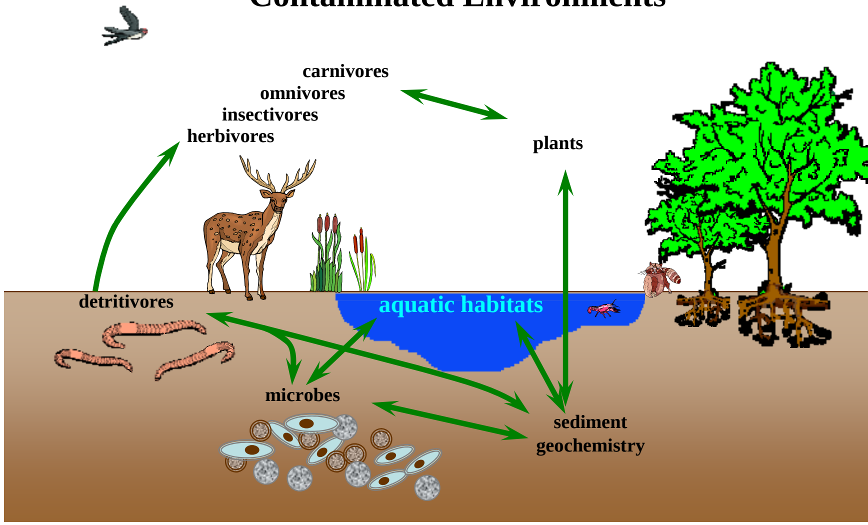
Tools and Approaches

Systems Biology
Biokinetic Models
DEB-Tox Models
Epigenetics
"-omic" Sciences

Hypothesis Driven Research Areas

Understanding mechanisms and processes
Biomarkers of exposure and effects
Understanding radiosensitivity
Multigenerational exposure and adaptation

Radiation Ecology
An Integrated, Systems Approach to
Contaminated Environments



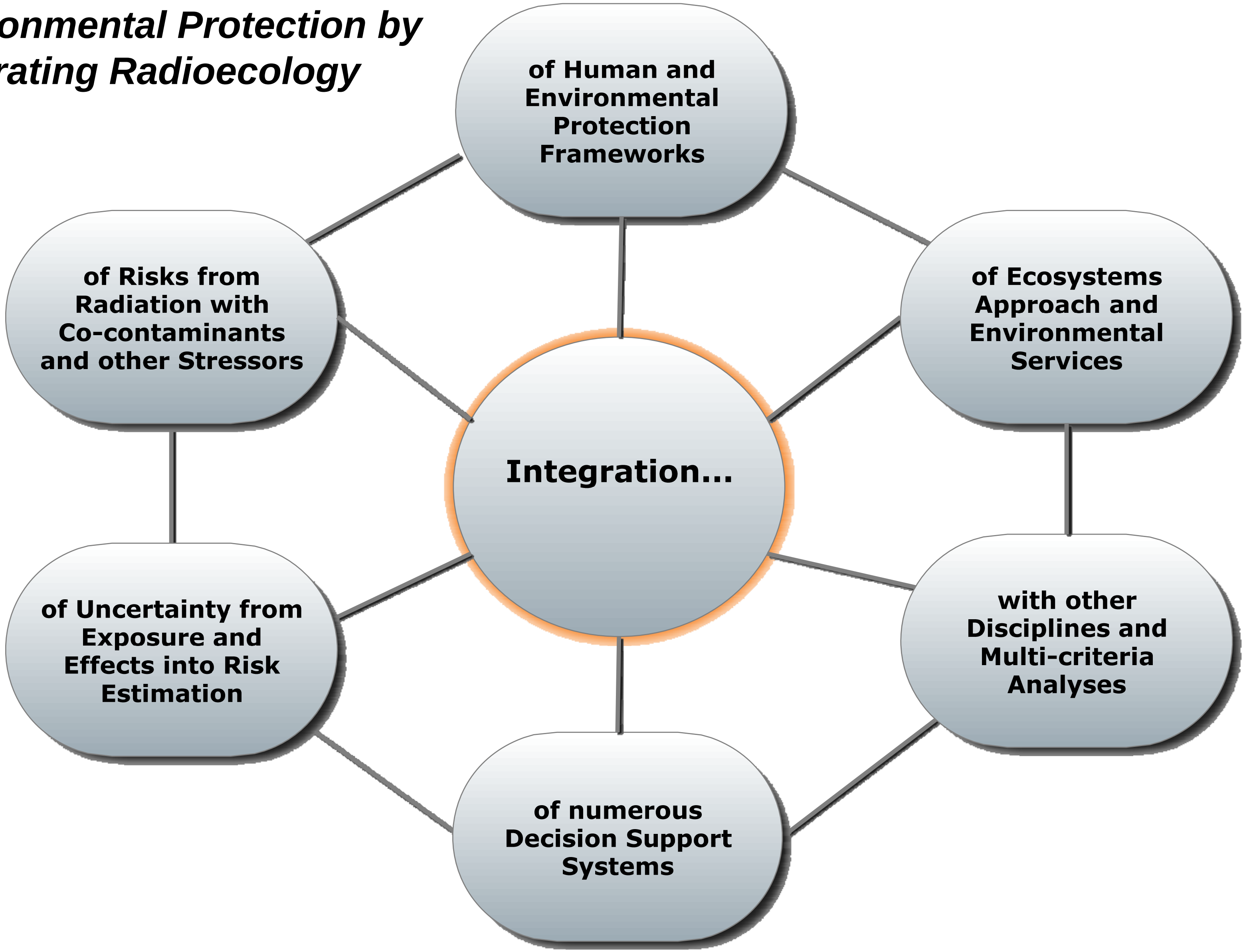
CHALLENGE THREE

To Improve Human and Environmental Protection by Integrating Radioecology

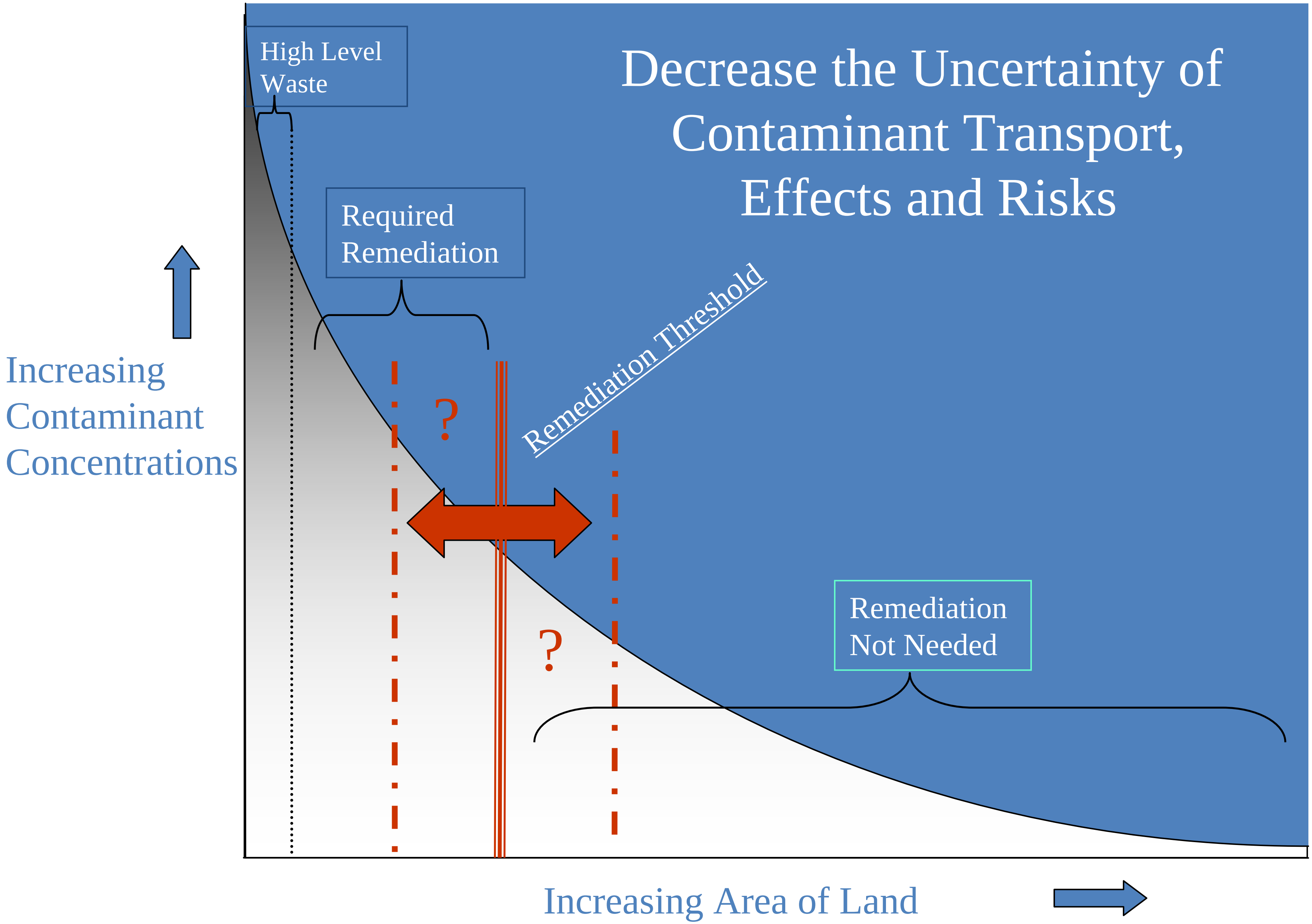
Our Strategic Vision is that over the next 20 years radioecology will develop the scientific foundation for the holistic integration of human and environmental protection, as well as their associated management systems.

CHALLENGE THREE

To Improve Human and Environmental Protection by Integrating Radioecology



Integrate Decision Support Tools and Optimize via Multi-criteria Analyses



NEXT STEPS

25 June to 1 October….we invite all stakeholders to download the SRA and a questionnaire to provide input (www.star-radioecology.org)

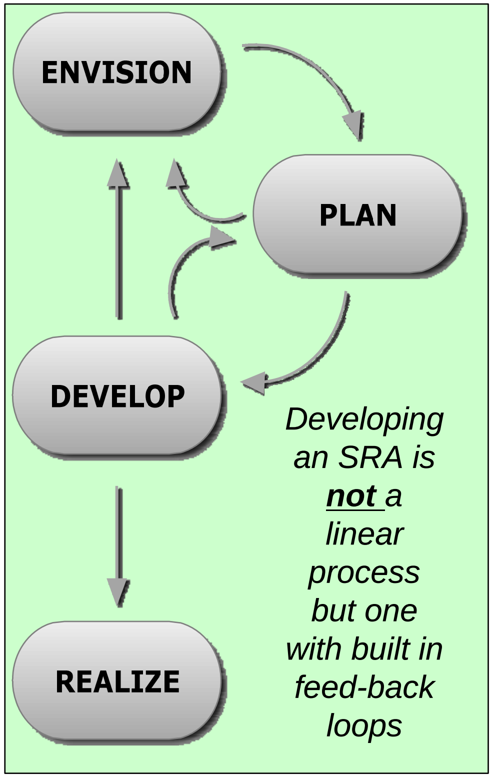
Build Consensus on the SRA

- STAR's External Advisory Board
- International Organizations (IAEA, ICRP, UNSCEAR, IUR)
- Other Networks of Excellence (DoReMi, NERIS, NCoRE)
- Larger radioecology community
- Interested stakeholders

12-13 November 2012….stakeholder workshop on SRA, Paris

Develop other aspects of the Strategic Agenda

- Education
- Recruitment
- Maintenance of key infrastructures
- Knowledge management



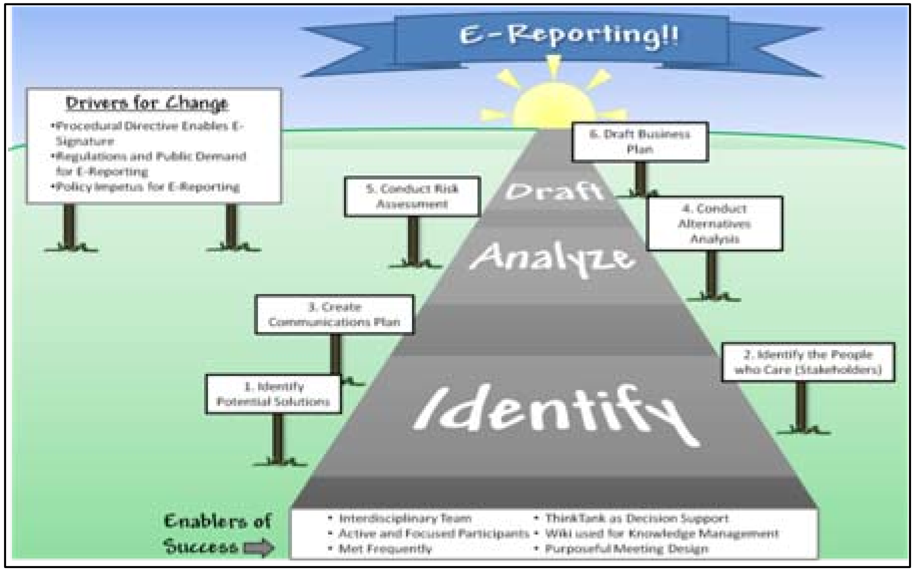
Next draft due **January 2014**

Develop a ROADMAP for the SRA

April 2013 --- July 2015

…the how and means of accomplishing the research items within the SRA…

The **Roadmap** will link the SRA with the evolution of the science by providing the necessary **action plans**, **resource allocation**, and **milestones** required to achieve the components of the SRA



EUROPEAN RADIOECOLOGY ALLIANCE

STAR has produced the first *Draft* Strategic Research Agenda in Radioecology !!

3 Scientific Challenges….with15 associated research lines

An SRA for radioecology will focus and prioritise our collective efforts… enhancing value to stakeholders and more rapidly advancing our understanding of environmental radioactivity

STAR
STRATEGY FOR ALLIED RADIOECOLOGY

CHALLENGE ONE: Quantify Key Processes that Most Influence Radionuclide Transfers

Strategic Research Agenda

1. Identify and mathematically represent key processes that make significant contributions to the environmental transfers of radionuclides and resultant exposures of humans and wildlife.

2. Acquire the data necessary to parameterise the key processes that control the transfer of radionuclides.

3. Develop transfer and exposure models that incorporate physical, chemical and biological interactions, and enable predictions to be made spatially and temporally.

4. Represent radionuclide transfer and exposure at a landscape or global environmental level with an indication of the associated uncertainty.

Determine Ecological Consequences under Realistic Exposure Conditions

Strategic Research Agenda

1. Mechanistically understand how processes link radiation induced effects in wildlife from molecular to individual levels of biological complexity.

2. Understand what causes intra- and inter-species differences in radiosensitivity (among cell types, tissues, life stages, among contrasted life histories, influence of ecological characteristics including habitats, behaviour, feeding regimes).

3. Understand the interactions between ionising radiation effects and other co-stressors.

4. Understand the mechanisms underlying multi-generational responses to long-term ecologically relevant exposures (maternal effects, hereditary effects, adaptive responses, genomic instability, and epigenetic processes).

5. Understand how radiation effects combine at higher levels of biological organisation (population dynamics, trophic interactions, indirect effects at the community level, and consequences for ecosystem functioning).

Improve Human and Environmental Protection by Integrating Radioecology

Strategic Research Agenda

1. Integrate uncertainty and variability from transfer modelling, exposure assessment and effects characterisation into risk characterisation.

2. Integrate human and environmental protection frameworks.

3. Integrate the risk assessment frameworks for ionising radiation and chemicals.

4. Provide a multi-criteria perspective in support of optimised decision-making.

5. Integrate ecosystem services, ecological economics and ecosystem approaches within radioecology.

6. Integrate Decision Support Systems