Confidence
Coping with uncertainty for improved modelling and decision making in nuclear emergencies

EUROPEAN JOINT PROGRAMME FOR THE INTEGRATION OF RADIATION PROTECTION RESEARCH
CONCERT

Decision making during the transition phase: establishment and optimisation of remediation strategies - agricultural area

Scenario-based workshop

Milagros Montero; Cristina Trueba; Roser Sala (CIEMAT)

Training course

Use of uncertain information by decision makers at the various levels within the decision making process and its communication

VUJE, 13 - 15 May 2019. Trnava, Slovakia

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287

Topics and objectives

Topics:

- Agricultural area recovery
  - Issues in the agricultural areas contaminated
  - Pathway exposure through food-chain

Objectives:

- Identify the critical aspects in the preparedness and response for the recovery during the transition phase
- Approach to dealing with the uncertainties arisen in the transition phase, to prepare plans for subsequent recovery
- How these criteria and their uncertainties could be taken into account in the post-accident decision making on recovery management

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Topics for discussion

- What do we understand by “the transition phase”
- Main concerns during the transition phase
- Issues to be addressed during the transition phase:
  - Food and water control
  - Radiological characterization of the contaminated areas
  - Radioactivity surveillance/monitoring programs
  - Planning and implementation of recovery strategies
  - Socio-economic implications
  - Communication management
- Objectives and criteria of the restoration plan
- Alternative restoration actions
- Stakeholders engagement

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Scenario

- Scenario is situated during the transition phase after an hypothetical severe nuclear accident in the Trillo NPP (Spain), with external release of radioactivity to environment.
- The release has ceased, the control over the source has been taken and urgent protective measures have been implemented to avoid the exposure to population, including evacuation, access restrictions and food restrictions.
- The radioactive contamination has spread in the surroundings of the damaged NPP and transported and dispersed through near regions, affecting a both inhabited areas and relevant agricultural and farming systems.
- The contamination level, range of contamination and affected areas have been identified.
- The release date is close to the dates of the harvest season resulting in a significant radiological contamination in large agricultural and grazing areas and with potential to affect to the population through the food-chain along several years.
- It has to be decided how to proceed in such a situation. The actions to be taken will be focused on mitigating the consequences of the contamination and on preparing recovery plans on the agricultural areas and the food-chain affected.

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Territorial scope of action

- Severe accident in the Trillo NPP
- Release date: 6th July 2017 00:00
- Deposition and consequences modelling using JRODOS

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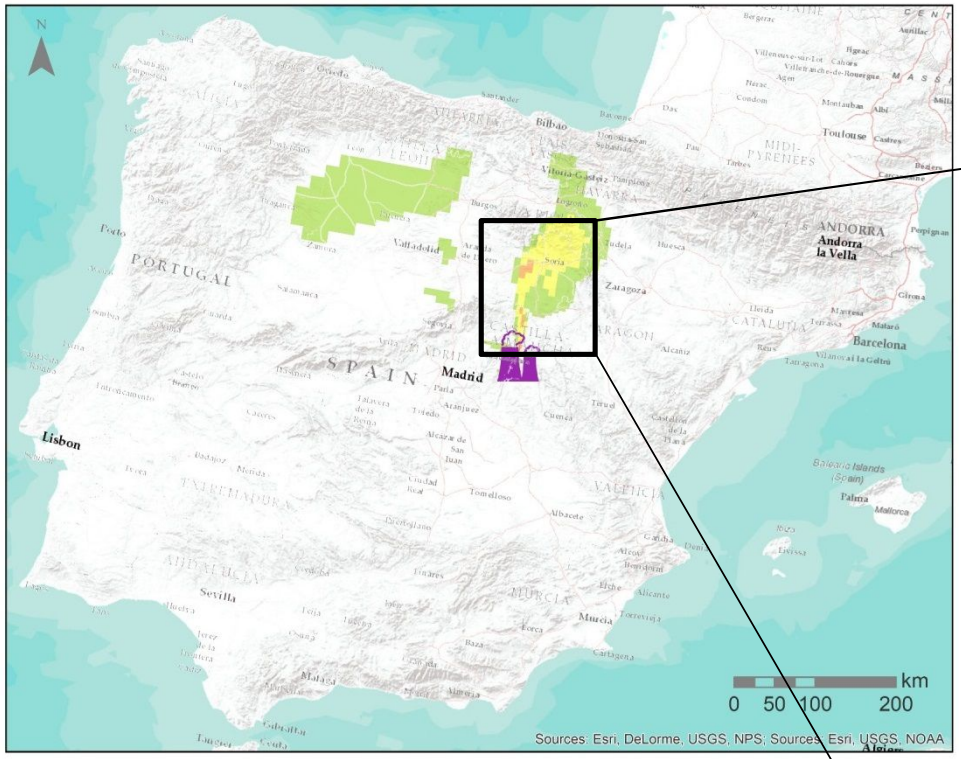
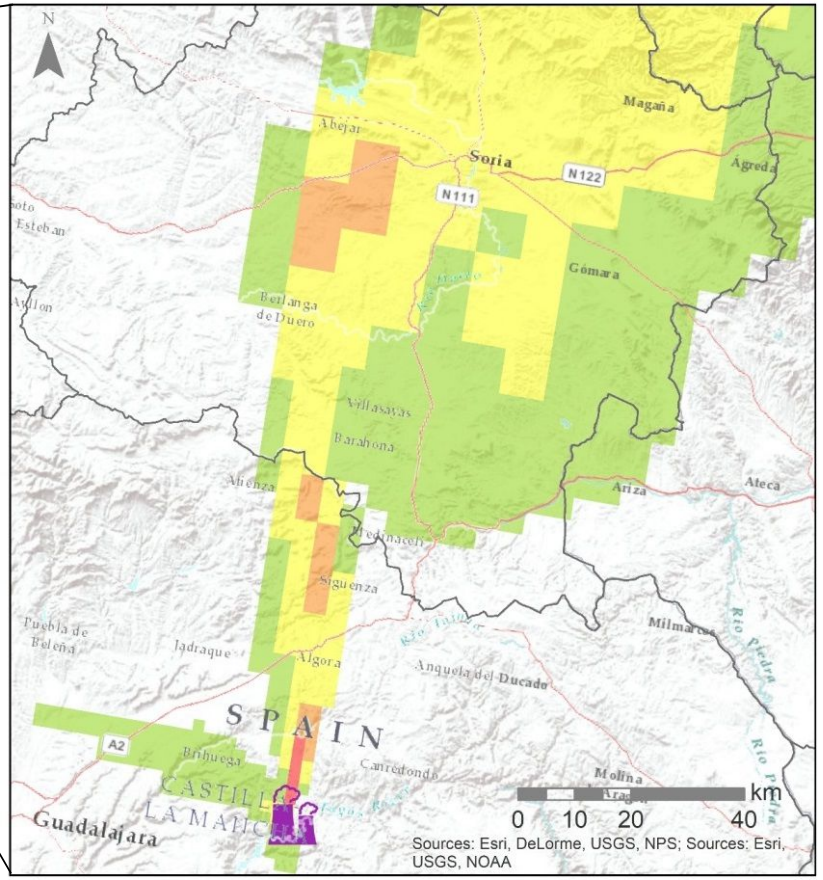
Scenario Trillo (release: July 6 at 00:00)

ground contamination (dry+wet) [Bq/m^2] for Cs137 at ~ 3 days after start of release





Contamination levels	Map key	Total deposition Cs137 [kBq/m^2]
Extremely contaminated		> 10.000
Heavily contaminated		1.000 - 10.000
Contaminated		100 - 1.000
Slightly contaminated		10 - 100
Non-contaminated		< 10

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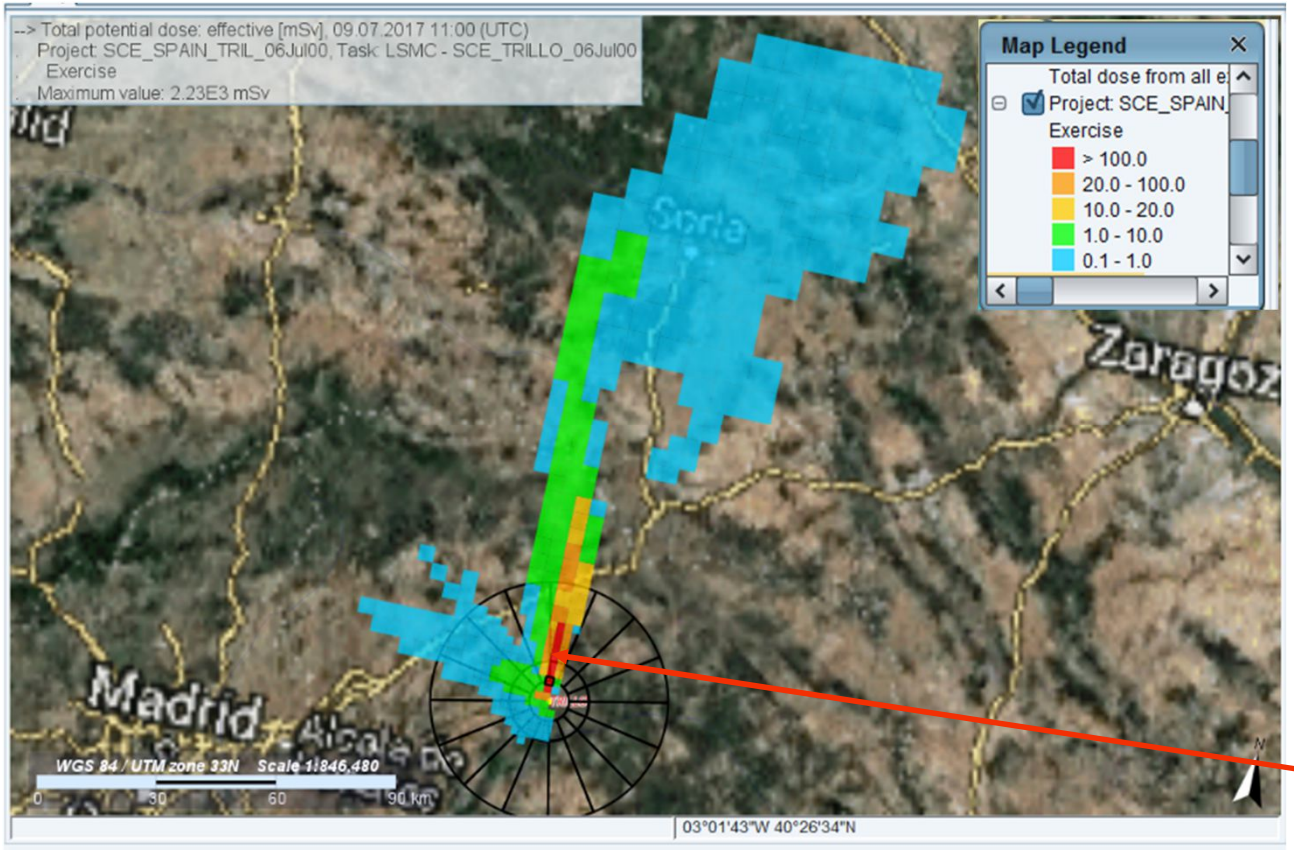
Scenario Trillo (release: July 6 at 00:00)

Total potential effective dose [mSv] for Cs137 at ~ 3 days after start of release



Total Effective Dose (short term) [mSv]

≥ 100 mSv
Evacuation

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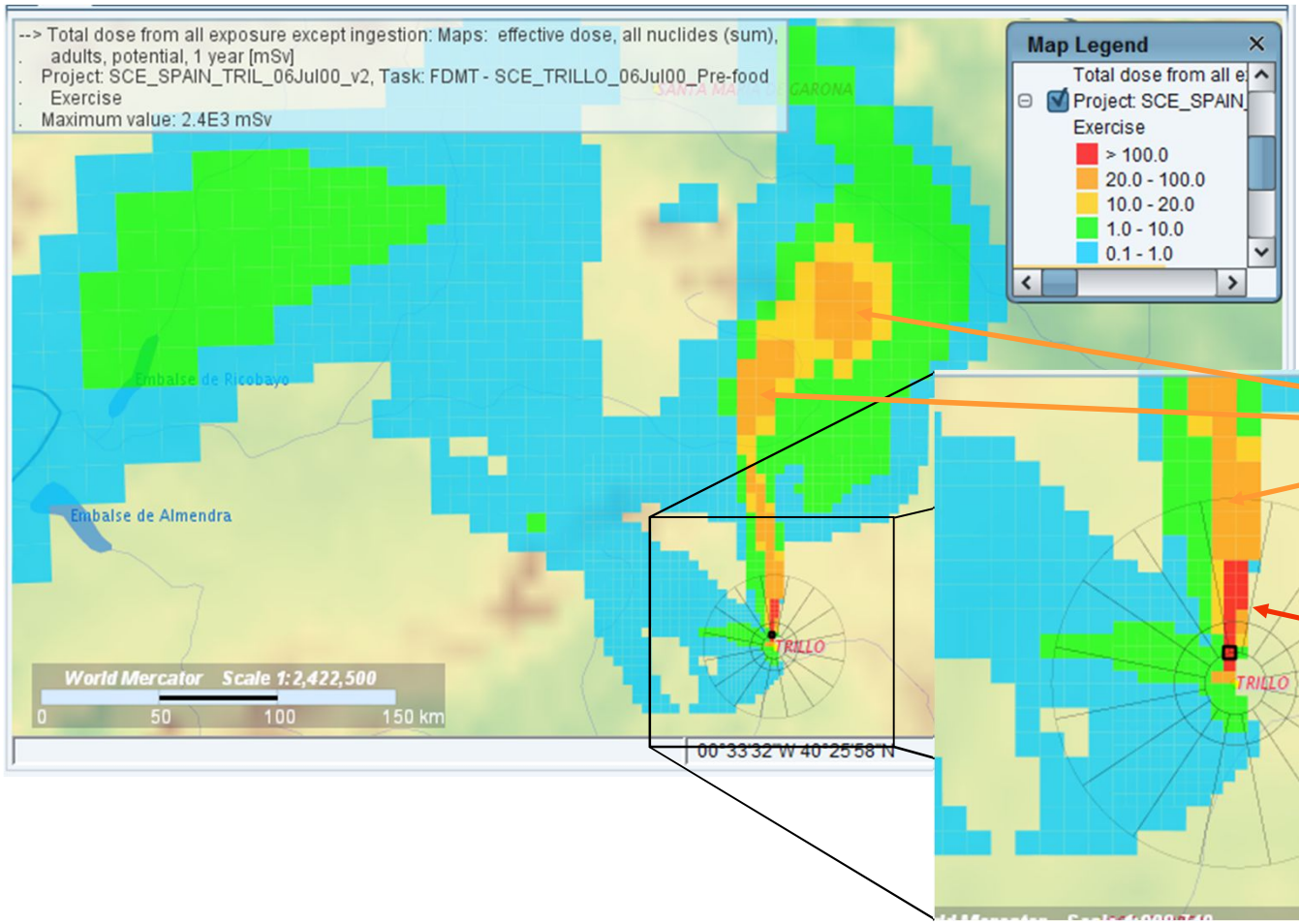
Scenario Trillo (release: July 6 at 00:00)

Total potential effective dose, except ingestión) [mSv] for Cs137 at 1 year after start of release



Total effective dose through all pathways (except ingestion) (long-term) (1 y) [mSv]

20 - 100 mSv
Restriction of use

≥ 100 mSv
Definitive Relocation

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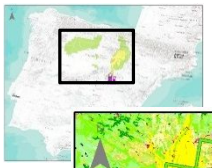
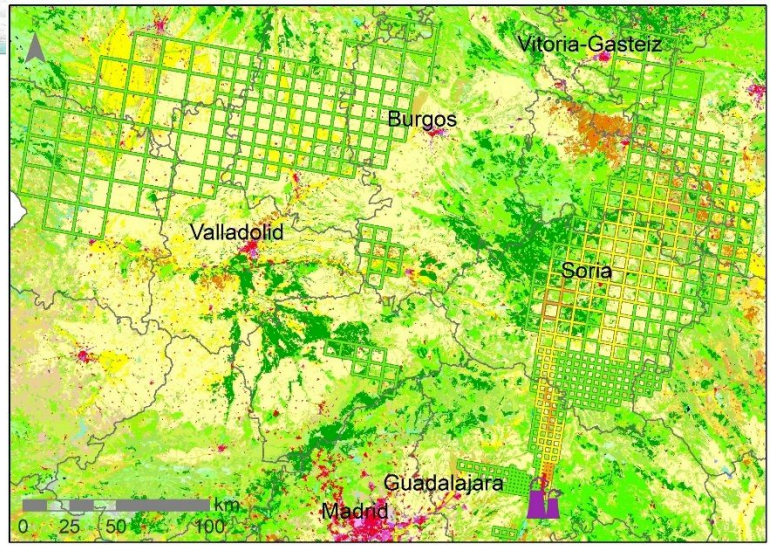
Land uses affected



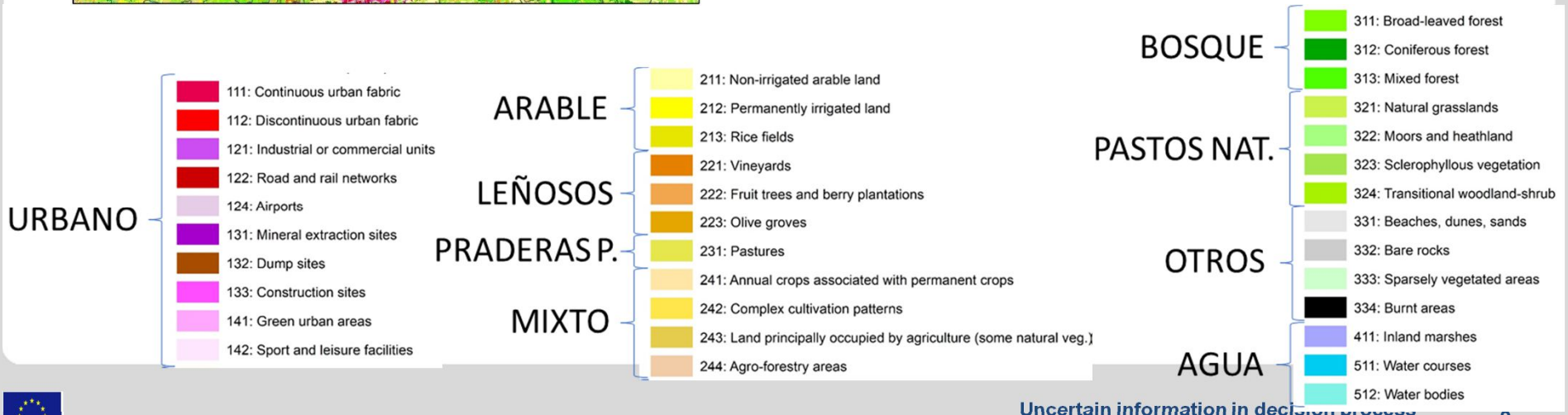
CORINE LAND COVER 2012



LAND USE CORINE	TOTAL AFFECTED SURFACE AREA ACCORDING TO THE DEPOSITION LEVEL (km^2)*				
	2	3	4	5	TOTAL
Urban	305	24	1	0	330
Arables crops	15.285	1.433	125	12	16.856
Permanent crops	543	129	0	0	673
Mixed	1.207	137	4	4	1.353
Natural grasslands	3.782	1.715	129	4	5.629
Pastures	344	38	0	0	382
Forest	3.894	1.510	122	4	5.529
Water	115	12	2	0	129
Other	147	50	1	0	198
Total	**25.475**	**4.998**	**383**	**24**	**31.079**

*Considering the whole surface area of municipalities with contaminated areas.

Source: Spanish Annual Statistical Book



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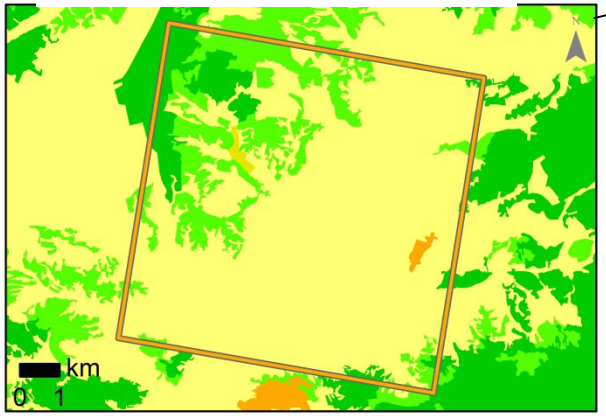
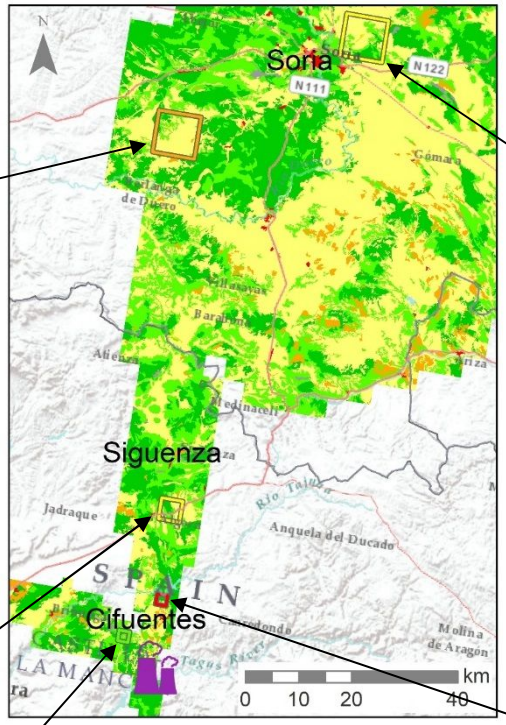
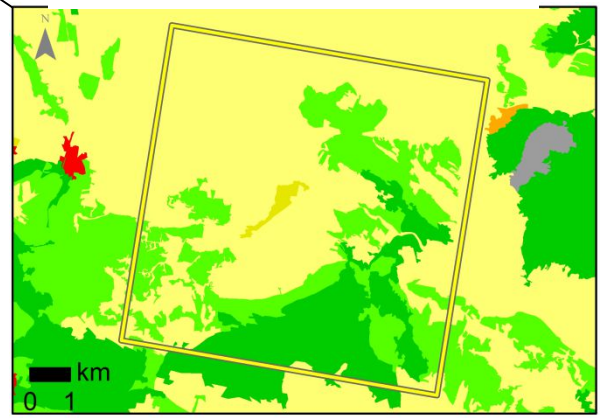
Location of representative agricultural areas affected

CELL #3500: GRAZING
(DEPOSIT LEVEL 4)

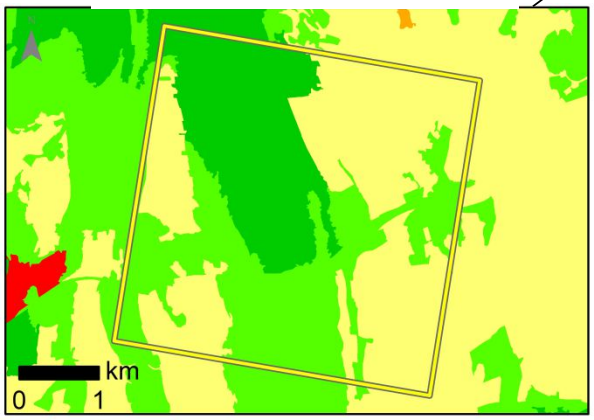




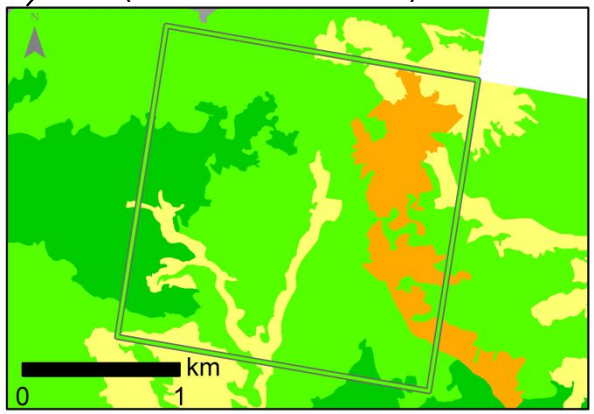
CELL #3660: AGRICULTURAL
(DEPOSIT LEVEL 3)



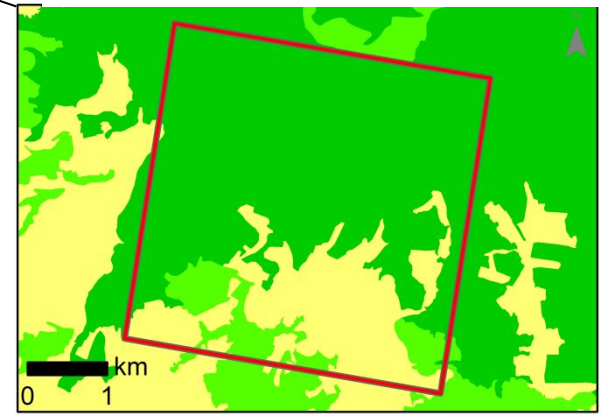
CELL #1399: GRAZING
(DEPOSIT LEVEL 3)



CELI #246: GRAZING
(DEPOSIT LEVEL 2)



CELL #329: GRAZING & FOREST
(DEPOSIT LEVEL 5)



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Agricultural and husbandry production

MUNICIPALITY	SURFACE AREA OF CROPS AFFECTED (Ha)								
	CEREALS	LEGUMINOUS	VEGETABLES	INDUSTRIAL CROPS	FODDER CROPS	FRUIT	VINEYARD	OLIVE	OTHER PERMANENT CROPS
GUADALAJARA	189.932	7.176	595	32.989	1.004	21.846	1.658	17.314	41
SORIA	223.995	6.010	1.012	39.868	3.824	892	1.374	-	-

MUNICIPALITY	NUMBER OF CATTLE	BEEF COW (Tm)	COW MILK
	TOTAL	CARCASS WEIGHT TOTAL	(1E3 liters)
GUADALAJARA	2.308	3,16	478,27
SORIA	19.653	433,55	2.133,28

FUENTE: ANUARIO DE ESTADÍSTICA. CAPÍTULO 14

PROVINCIA	NUMBER OF SHEEP	SHEEP MEAT (Tm)	SHEEP MILK
	TOTALES	CARCASS WEIGHT TOTAL	(1E3 litres)
GUADALAJARA	38.496	494,71	879,56
SORIA	170.795	397,62	399,18

FUENTE: ANUARIO DE ESTADÍSTICA. CAPÍTULOS 13 e INE 2009

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Food-chain: Relevant pathways and Indicators to evaluate them

Indicators to evaluate the radiological impact and the consequences of the contamination

- Total deposition of Cs137.
- Concentrations of activity in food and feed and space-time evolution.
- Contribution of each food to the effective annual dose for ingestion.
- Affected area.
- Affected population.
- Environmental, social and economic impacts

Relevant pathways

- Pasture-lamb-milk-cheese
- Pasture-cow-milk-cheese
- Pasture-cow-beef
- Wheat-flour

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Concentration of activity in selected cells

cell	#246	#3660	#1399	#3500	#329
Total Ground deposition [Bq/m^2]	4,20E+04	4,18E+05	6,22E+05	1,25E+06	1,27E+07
Contamination level	2	3	3	4	5

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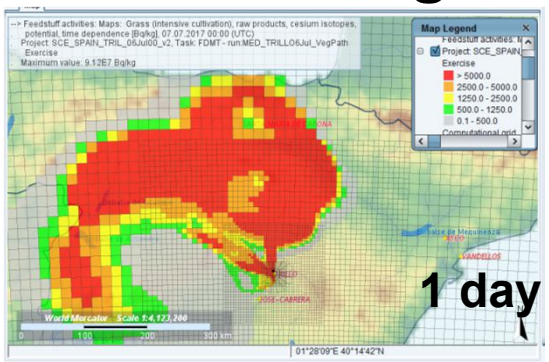
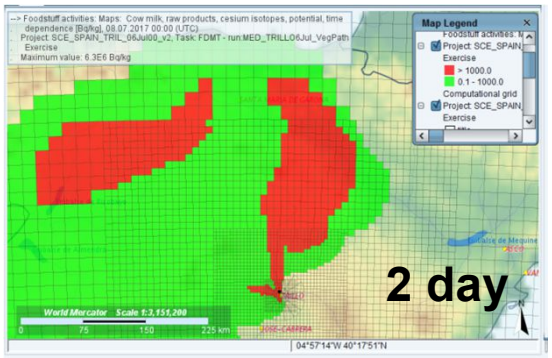
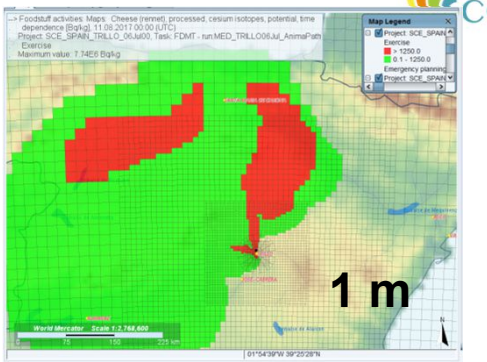
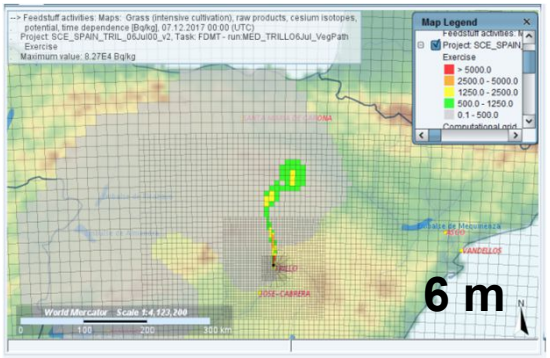
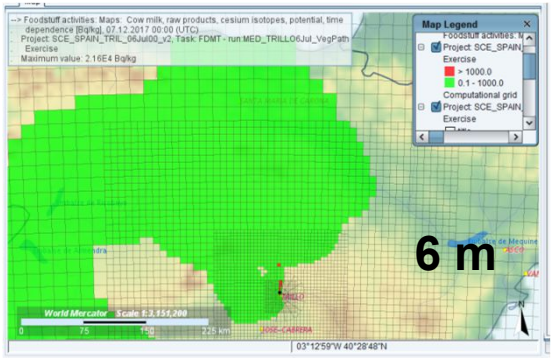
Temporal evolution of the activity concentration of Cs-137 in agricultural products

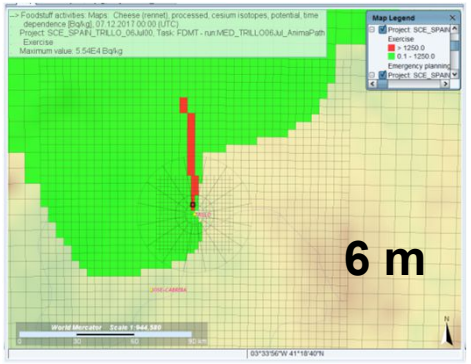


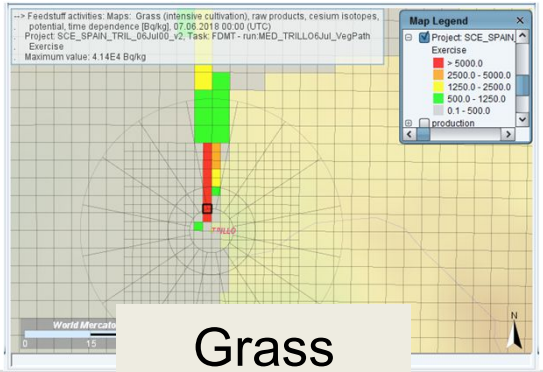




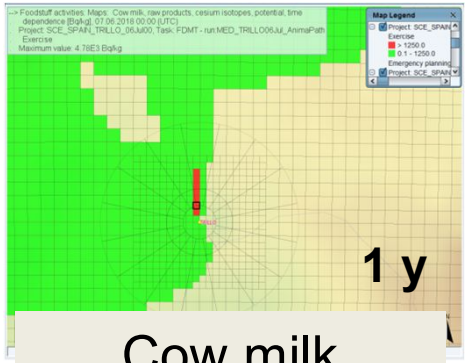




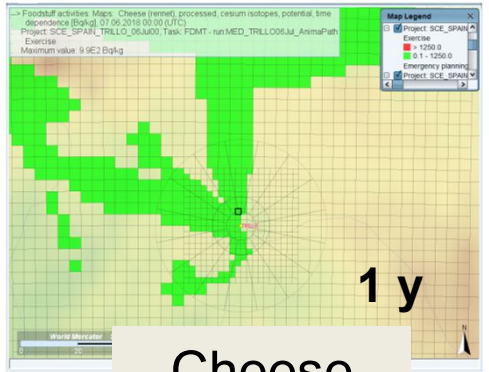




Grass



Cow milk



Cheese

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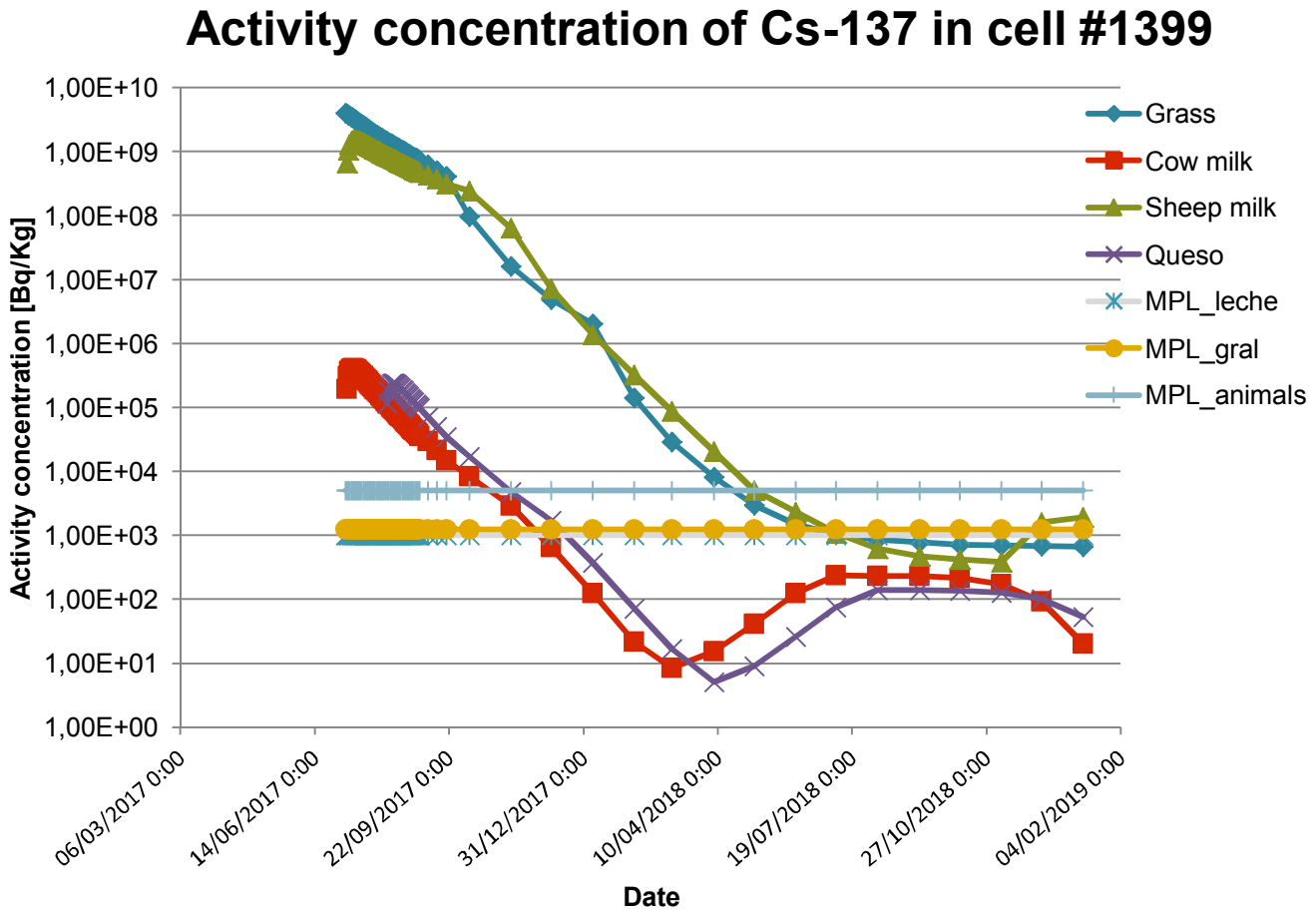
Temporal evolution of the activity concentration in cell #1399



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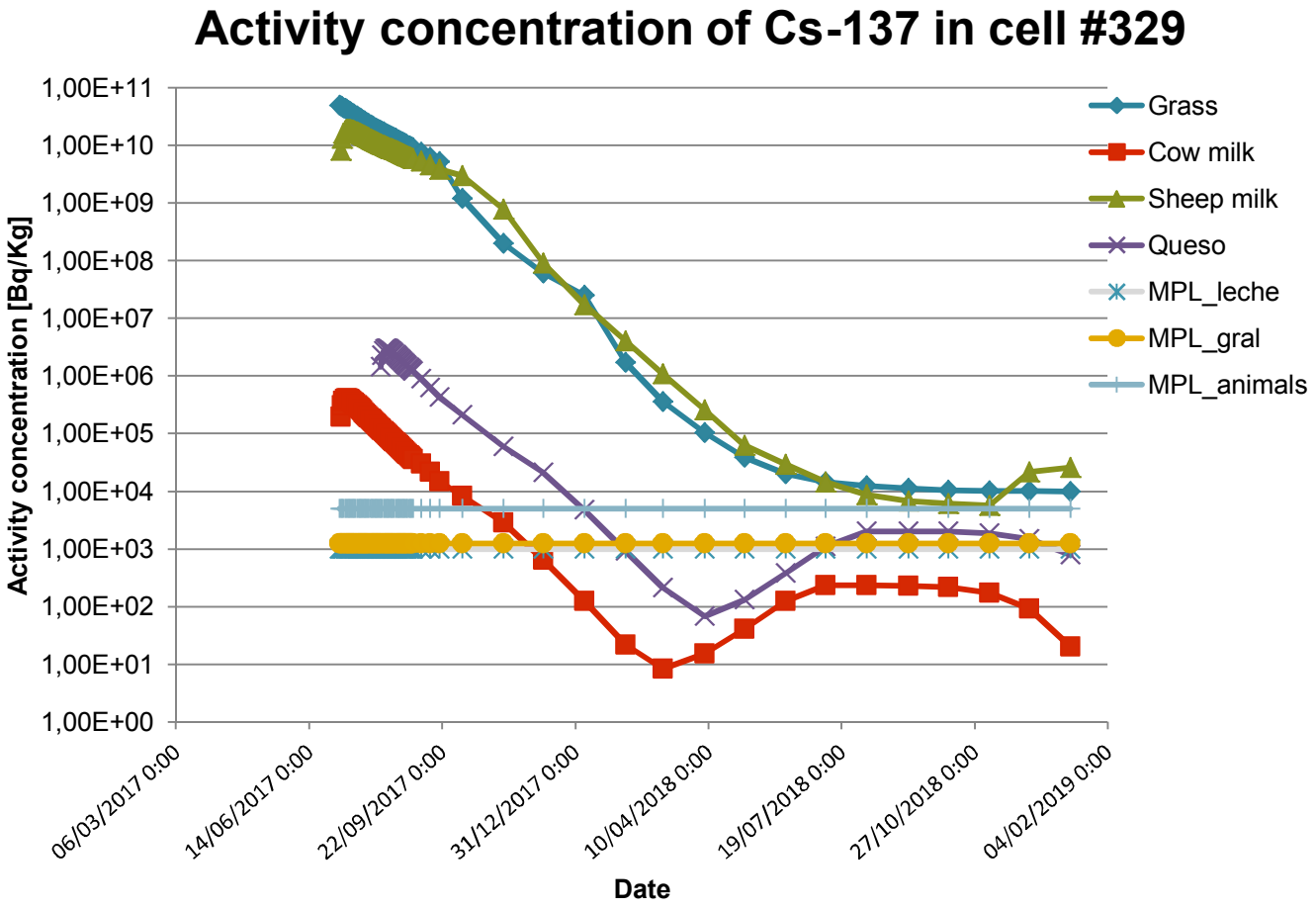
Temporal evolution of the activity concentration in cell #329



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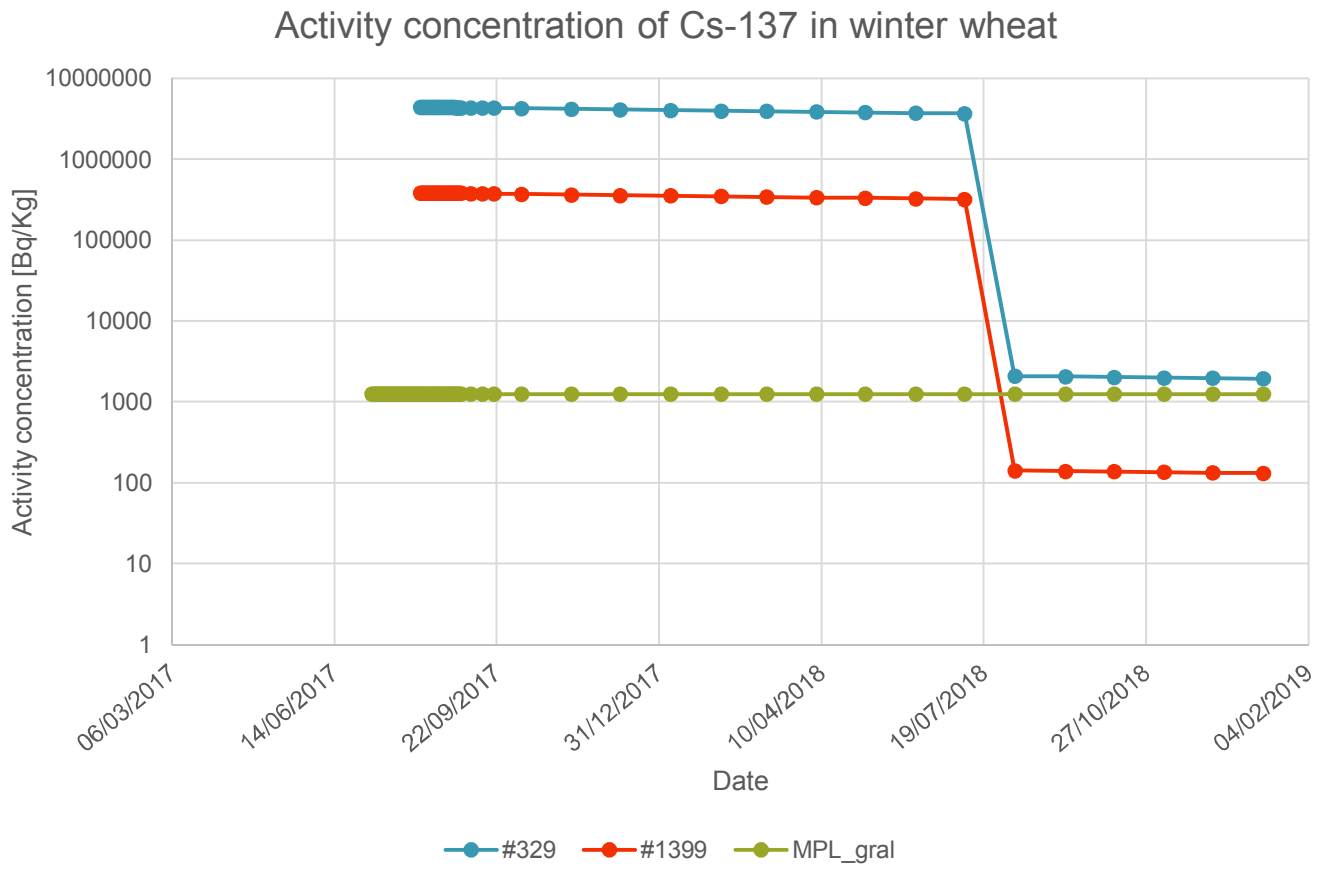
Temporal evolution of the activity concentration in Winter wheat



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Recovery alternatives

- Do nothing, implementing a monitoring strategy

- On the Soil, to reduce the transfer of contamination to the food-chain:
  - Chemical treatments: Application of Potassium fertiliser
  - Mechanical treatments:
    - Deep ploughing
    - Top soil removal
- On the cattle, to reduce the activity concentration on the animal products:
  - Supply clean fodder
  - Administration of AFCF
- On the foodstuffs:
  - Proccesing of milk for human consumption

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Facilitated discussion questions

- Which are the main concerns: health, environmental, social, economic, ...?
- What are the objectives to pursue, in the context of the decision that is being considered?
- What are the key criteria for selection of strategy?
- What are the main uncertainties influencing the decision?
- Choosing/prioritisation the strategy and taking into account the inherent uncertainties on:
  - the knowledge of the real consequences of an accident based on exercise scenario,
  - goal and criteria during the development of strategies on protective actions and their implementation
  - the strategies to be implemented, and
  - the potential socioeconomic impact on the affected population)
- How these criteria and their uncertainties could be taken into account in the post-accident decision making on recovery management

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Support Material

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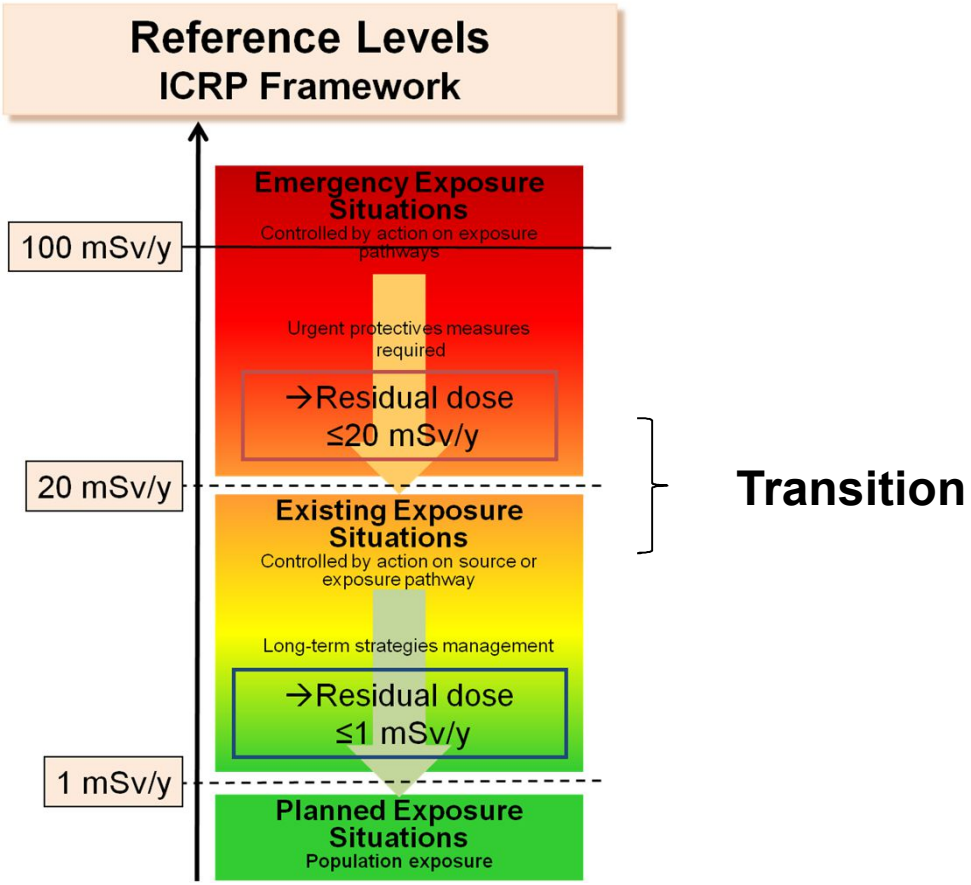
Reference levels (ICRP Framework)



Framework categorising reference levels to use in existing and emergency exposure situations.

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Contamination levels (deposition)

Contamination levels	Map key	External dose rate [µSv/h]	Total deposition Strong gamma and beta emitters together [kBq/m^2]	Total deposition Alpha emitters, [kBq/m^2]
Extremely contaminated		> 100	> 10.000	> 100
Heavily contaminated		10 - 100	1.000 - 10.000	10 - 100
Contaminated		1 - 10	100 - 1.000	1 - 10
Slightly contaminated		< 1	10 - 100	0,1 - 1
Non-contaminated		fondo	< 10	< 0,1

1) Is is assumed that radioactive material is still on the surfaces of soil, buildings, goods, etc, and have not migrated deeper into the soil or other material.

REF: NGR. Protective measures in early and intermediate phases of a nuclear or radiological emergency. Nordic Guidelines and Recommendations. 2014

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Generic Criteria and OILs to take actions

Protective action	Generic criteria				OILs	Consideration
	For taking the action		To adapt / lift the action		To adapt / lift the action	
	E	Hfetus	E	Hfetus (para 9 m)		
Evacuation	≥ 100 mSv (7d)	≥ 100 mSv (7d)	≥ 100 mSv (1y)	≥ 100 mSv	≥ OIL2	Substituting evacuation with relocation
			< 100 mSv (1y)	< 100 mSv	< OIL2	Lifting the evacuation. Take othe actions (decontamination)
			≤ 20 mSv (1y)	≤ 20 mSv	< OIL_T	Lifting the evacuation and terminate the emergency.
Realojo	≥ 100 mSv (1y)	≥ 100 mSv (9m)	< 100 mSv (1y)	< 100 mSv	< OIL2	Lifting the evacuation. Take othe actions (decontamination)
			≤ 20 mSv (1y)	≤ 20 mSv	< OIL_T	Lifting the evacuation and terminate the emergency.
Food, milk and drinking water restrictions in affected areas	≥ 10 mSv (1y)	≥ 10 mSv (9m)	< 10 mSv (1y)	< 10 mSv	< OIL6	Lifting after estimating the actual doses from the ingestion pathway and their contribution to the residual dose from all exposure pathways
Food, milk and drinking water restrictions for international trade	≥ 1 mSv (1y)	≥ 1 mSv (9m)	< 1 mSv (1y)	< 1 mSv	< MPL	Lifting of the restrictions on international trade of foods and feedstuffs
Local restrictions on non-food commodity	≥ 10 mSv (1y)	≥ 10 mSv (9m)	< 10 mSv (1y)	< 10 mSv	< OIL_C	Lifting after estimating the actual doses for the use and their contribution to the residual dose from all exposure pathways
Non-food commodity restrictions for international trade	≥ 1 mSv (1y)	≥ 1 mSv (9m)	< 1 mSv (1y)	< 1 mSv	< OIL_C	Lifting of the restrictions ontrading non-food commodities internationally

E – Effective dose.
Hfetus – Equivalent dose to the fetus

REF. Arrangements for the termination of a nuclear a radological emergency. IAEA GSG-11

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Criteria for food and feed control

Maximum permitted levels (MPL) of radioactive contamination of food and feed following a nuclear accident or any other case of radiological emergency (Commission Regulation (Euratom) 2016/52, 15 January 2016)

Maximum permitted level of radioactive contamination [Bq.Kg^{-1}]							
	Food Group				Feedstuffs, according the animal consuming it		
Isotope group	Infant food	Dairy produce	Other food for general consumption	Liquid food	Pig farming	Poultry, lambs, calves	Other
All other nuclides ($T_{1/2}$ < 10 d), notably Cs-134 and Cs-137	400	1000	1250	1000	1250	2500	5000
Isotopes of iodine, notably I-131	150	500	2000	500			
Isotopes of strontium, notably Sr-90	75	125	750	125			
Alpha-emitting isotopes, notably Pu-239 and Am-241	1	20	80	20			

The levels for food derive from a dose level (CR) of 1 mSv / year and assuming that 10% of the diet, during the year following the emergency, is contaminated.

https://eur-lex.europa.eu/legal-content/ES/TXT/?qid=1531135147792&uri=CELEX:32016R0052

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Agricultural countermeasures (selection from EURANOS Handbook)

OBJECTIVES	EFFECTIVENESS	FEASIBILITY	WASTE	SIDE-EFFECTS	COSTS	SOCIAL FACTORS
Application of potassium fertilizers to arable soils and grasslands						
Reduce plant uptake of Cs-137 by addition of K fertilizers	Reduction factor up to 5 (80%) when the exchangeable K status < 0.5meq/100g soil	Requires specific equipment, ancillary, utilities, consumables	None	Environmental (mobility of nutrients-water quality), impact		Farmer/food industry/consumers resistance
Application of lime to arable soils and grassland						
Reduce plant uptake of some RN by addition of lime to the soil	Liming from pH 5 to 7, may decrease plant uptake of Sr-90 by: 50% (factor of 2)-sandy soils 67% (factor of 3)-loamy soils 75% (factor of 4)-clay soils 83% (factor of 6)-organic Liming in excess pH7/6 has no effect	Requires specific equipment, ancillary, utilities, consumables	None	Environmental (mobility of nutrients-water quality), agricultural (soil fertility) impact		Public/farmer resistance
Deep ploughing						
Reduce RN uptake by crops, including pasture	Uptake reduced by up to 90% (factor of 10) External dose reduced by 50-95% (factors of 2-20=	Requires plough, tractor, consumables	None	Environmental, agricultural impact		Public confidence due to contamination at depth
Top soil removal						
Reduce RN uptake by crops, including pasture	90-97% of the activity is removed	Requires bobcat, bulldozer, vehicle to transport waste, consumables	Yes. Needs to be disposed	Environmental (soil erosion), agricultural (soil fertility) impact		Farmer resistance (disruption of farming and waste)
Selection of edible crop that can be processed						
Select crops suitable for processing so that the final edible product has activity concentrations less than intervention levels	Varies regarding crop and RN; Food processing factor= total activity of RN in the processed food (Bq)/total activity of RN in the raw material (Bq)	Sowing/harvesting equipment, consumables; processing equipment	Depends on crops selected; includes food processing residuals	Environmental (change ecosystem), agricultural (change crop type) impact		Public confidence and acceptance on these foods processed

Agricultural countermeasures (selection from EURANOS Handbook)

OBJECTIVES	EFFECTIVENESS	FEASIBILITY	WASTE	SIDE-EFFECTS	COSTS	SOCIAL FACTORS
Administration of AFCF boli to rumiants						
To reduce activity concentrations of Cs in meat or milk below the intervention levels	Up to 80% in lamb and reindeer meat and goat milk; up to 70% reduction in cow milk	Administer by hand (sheep, cows and goats); dosing guns used for other intra-ruminal devices	None	Animal welfare; conventional farming practices can be mantained		Acceptability to farmers, food industry and consumers
Live monitoring						
To determine whether activity concentration in animals are below the intervention limits	Highly effective (near 100%) at excluding meat above intervention level from foodchain	Portable, preferably lead-shielded NaI detector linked to a single or multi-channel analyser with battery supply calibrated for animals	None	No direct impact other than a disruption to normal practice		Stigma associated to the affected area
Processing of milk for subsequent human consumption						
Produce milk products with activity concentrations less than intervention levels	Depends on the RN and the product. Milk products prepared by isolating the fat and/or protein from the aqueous fraction tend to be depleted in Cs and Icompared with raw milk.	Milk processing plant, milk tankers, waste treatment facilities, consumables	Percentage by mass of waste by-products	Parts of the processing plant may become contaminated		Public confidence
Dietary advice						
Dose reduction by giving advice on how to reduce their RN intake	Washing removes 10-90% (vegetables & fruit) Peeling 10-100% of U, AM; 80% Cs and 50-90% Sr (root vegetables) Blanching or boiling 50% Filleting and washing fish 80% of Ra	Normal cooking utensils	Not addressed	Loss of traditional activities, potential loss of home produced.		Positive consequences if the population has trust in institutions;

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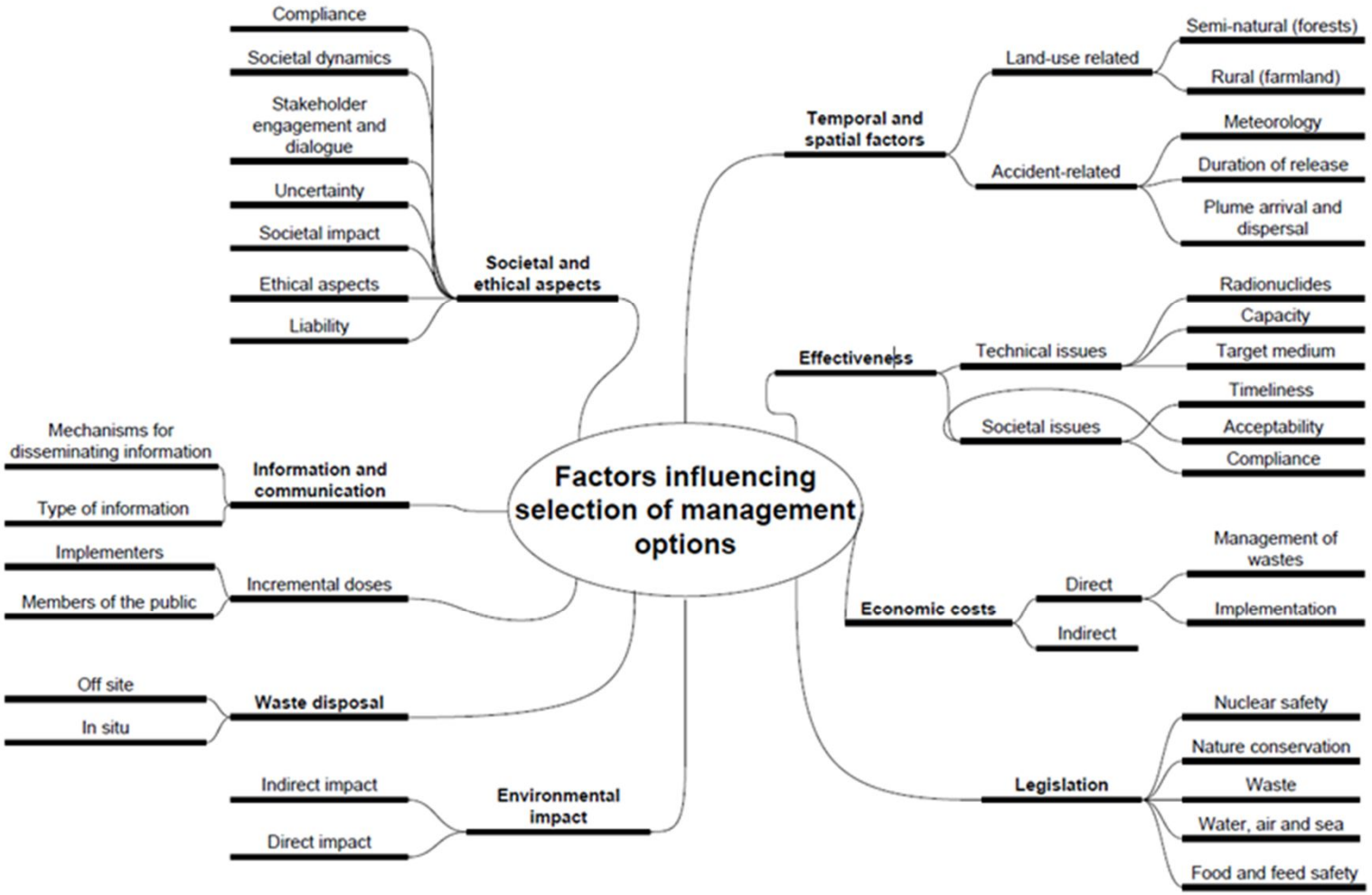
Factors influencing selection of management options (EURANOS Food Hanbook)



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Use of uncertain information by decision makers at the various levels within the decision making process and its communication

VUJE, 13 - 15 May 2019. Trnava, Slovakia

Confidence
Coping with uncertainty for improved modelling and decision making in nuclear emergencies

EUROPEAN JOINT PROGRAMME FOR THE INTEGRATION OF RADIATION PROTECTION RESEARCH
CONCERT

Decision making during the transition phase: establishment and optimisation of remediation strategies - agricultural area
Scenario-based workshop

Thank you for your attention!

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