Environmental risk assessment of plant pests integrating analysis of impacts on biodiversity and on ecosystem services

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Development of Guidance for the Environmental Risk Assessment (ERA)

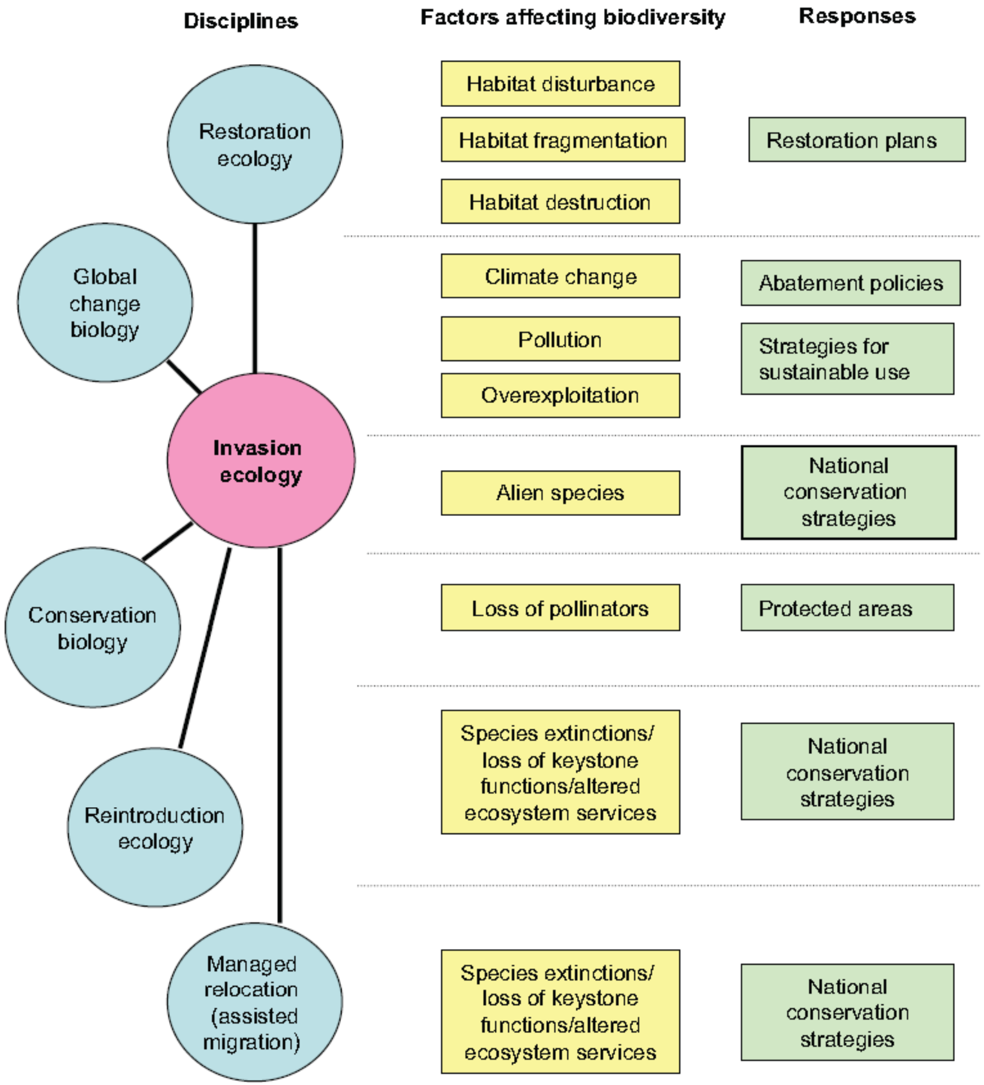
- Background
  - Every pest risk assessment (PRA) procedure includes the **assessment of environmental risk** and consequences of pests introduction and establishment
  - Great interest has been devoted to the **economic impact** of invasive plant pests, while less interest was allocated to their environmental impact
  - Despite extensive research effort there is **no standard and easily applied method to assess current/potential environmental impact of a plant pest** are available

Development of Guidance for the Environmental Risk Assessment (ERA)

- EFSA-PLH self task on ERA
  - Question No EFSA-Q-2010-00794
  - Adopted on 23 November 2011 (15 months)
  - Published in December 2011 in the EFSA Journal

- Objectives of the EFSA-PLH self task on ERA
  - **Develop a methodology** to prepare an environmental risk assessment of pests within PRA
  - Produce a complete **framework justifying the approach** and **provide guidance** for the assessment procedure

Environmental impact: the ecological perspective



- Invasion ecology has **emerged as a discrete field**, in connection with different areas of ecological research
- Invasive species are one of the **major threats** to biodiversity and ecosystem function
- Invasive species interact and **influence almost all factors affecting biodiversity**

Environmental impact: the ecological perspective

- Many principles and concepts are used in the context of ERA and management
  - They depend on the **perspective and the assumption** on the structure and functioning of biological communities and ecosystems
    - E.g. role assigned to functional redundancy

- In many cases principles and methods are useful in the context of defining **protection goals in general terms**

- They are not means for **determining specifically** what those protection/management goals should be
    - Which aspect are more valuated by a society
    - The degree of protection they deserve
    - The maximum level of impact

- Search for a specific **method supporting ERA** for plant pests

Environmental impact: the PRA perspective

- Elements qualifying a method (1/3)
  - **How to define the environment**, is it an object/value per se or is regarded as a mean for the fulfilment of human needs (utilitarian)
  - **How to define environmental impact**, there is still no clearness and agreement on the type and level of analysis that should be relevant to ERA
  - **How to assess the global impact**, there is the need to
    - **Integrate** the analysis of different aspects, and
    - **Express** impacts in a different way from the classical ecological units/variables (e.g., density, fluxes, diversity) (using integrative variables)

Environmental impact: the PRA perspective

- Elements qualifying a method (2/3)
  - Risk and not only impact
    - Instead of dealing with measure and analysis of ecological structure and processes we are dealing with **evaluation of the impact based on projections** of their probability of occurrence
    - The assessment is **based on a scenario analysis**, we are dealing with ongoing process of invasion or a possible event of arrival, establishment and spread, this requires a set of assumptions and knowledge on the possible future states and events
  - Method to define a **global environmental risk**: how integrate impact on different compartments and probabilities of occurrence
  - Opportunities for risk communication

Environmental impact: the PRA perspective

- Elements qualifying a method (3/3)
  - **Limited knowledge** available on the causal mechanisms leading to environmental consequences (associated **high uncertainties**)
  - **The complexity and the variety of mechanisms** involved in the environmental impact of invasive alien species **requires that each case is studied separately**. These are usually not possible within the usual framework and budget of a PRA
  - Assessment of the potential environmental impact of an invasive pest in a PRA is likely to **be based on expert judgements** for a long time to come

The EFSA-PLH approach

The review of the assessment scheme

- Every PRA scheme based on **ISPM11** includes an ERA of pest introductions
  - These schemes mainly focus on the effects on biodiversity, but do not present a clear definition of **what is biodiversity**
  - Do not provide a clear definition and an explicit standardised methodology for assessing the **consequences on ecosystem processes**

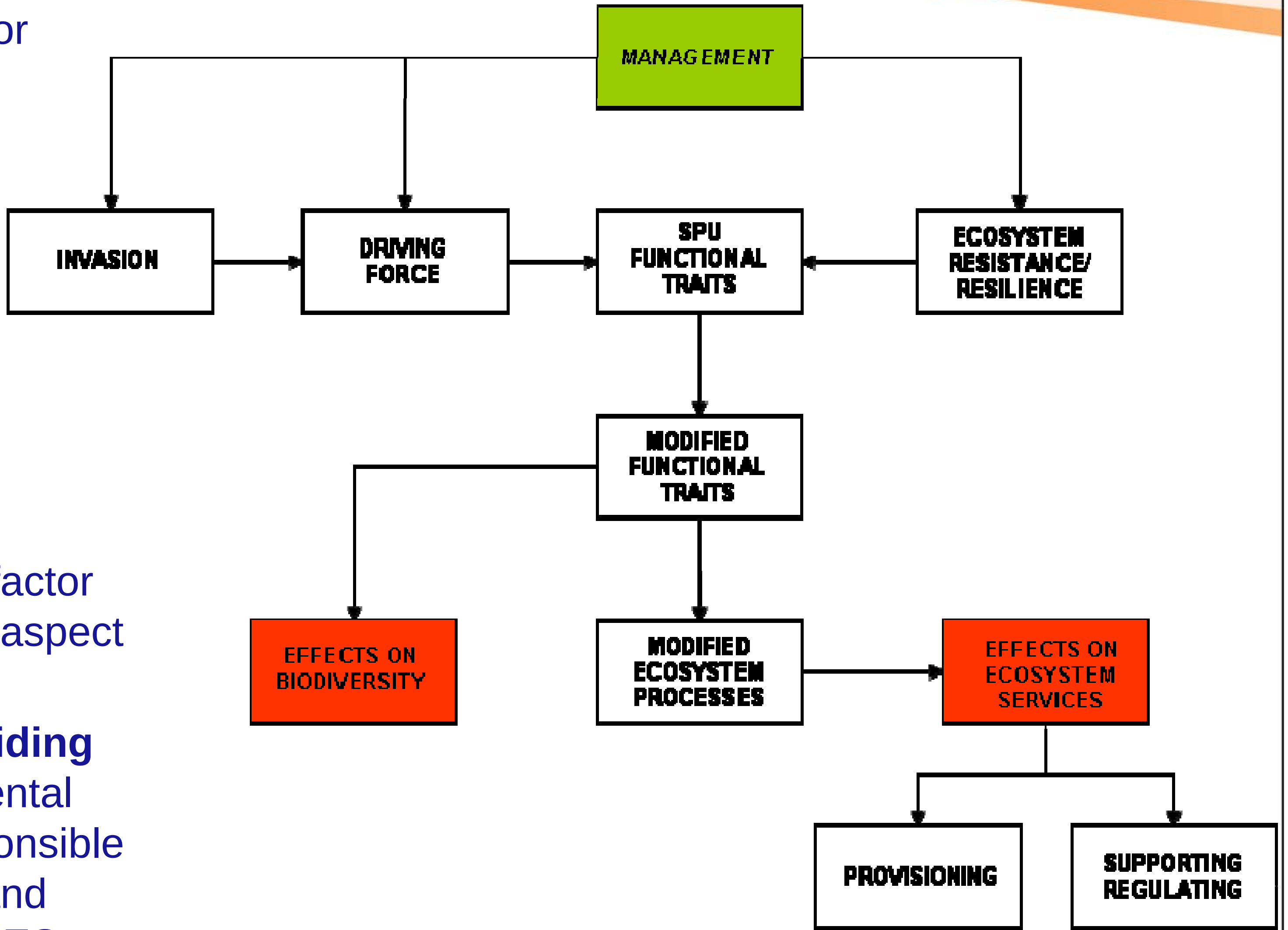
- The approach we are proposing provides a perspective that overcomes the contraposition between different philosophies and different approaches
  - **Compositionalism** → biodiversity oriented
  - **Functionalism** → ecological process oriented

The impact on structural biodiversity

- The EFSA-PLH approach recognises **importance** to consider the impact on the **structural biodiversity** at genetic, species, habitats, communities, and ecosystems levels
  - First, it allows **to account for the non-utilitarian value** of nature, addressing conservation related issues and considering the impact of on component of the natural capital
  - Second, the consideration of the impact on the natural capital is also a premise for the evaluation of the expected **contribution** of biodiversity (**functional biodiversity**) in ensuring systems have the capacity to cope with drivers of ecosystem change and **maintain desirable ecosystem functions** (and services)

How to frame an ERA based on ES

Stages/pathways for an ERA of invasive species based on biodiversity and ES



Driving force: any factor that changes an aspect of an ecosystem

SPU (Service Providing Unit): environmental component responsible for the genesis and regulation of the ES

How to frame an ERA based on ES

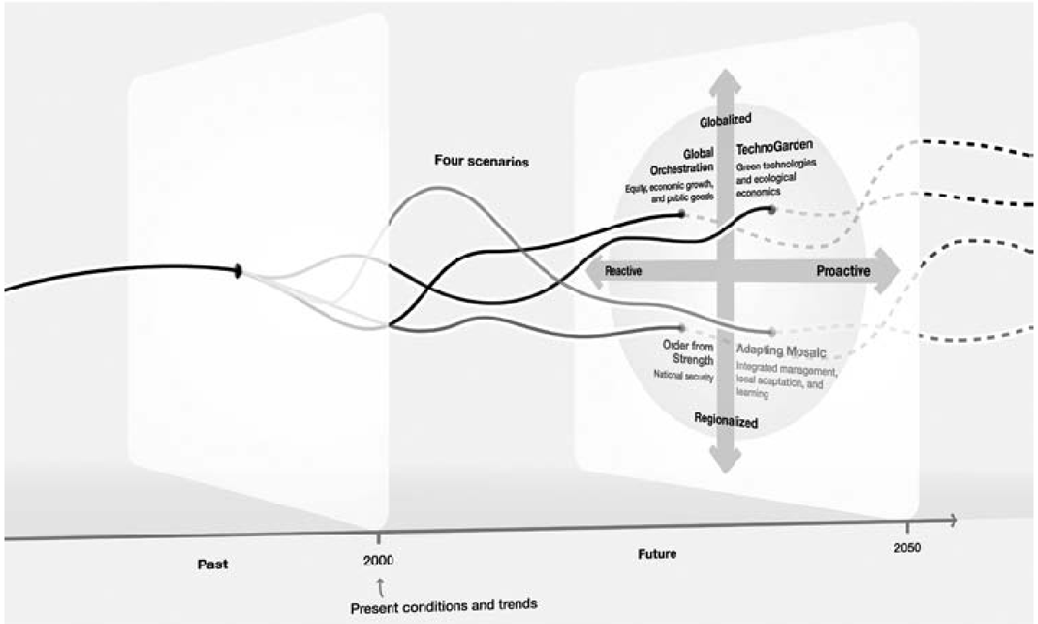
- The EFSA-PLH approach recognises role and importance to the ES level
  - The **ecosystem level** is the **most appropriate level of analysis** for invasive plant pest environmental impact
  - The concept of ES frames and summarizes **ecosystem properties** of the environment relevant to **human wellbeing and interests**
  - The potential impact of this type of driver of ecological change can be fruitfully assessed in terms of **modification of ES provision**

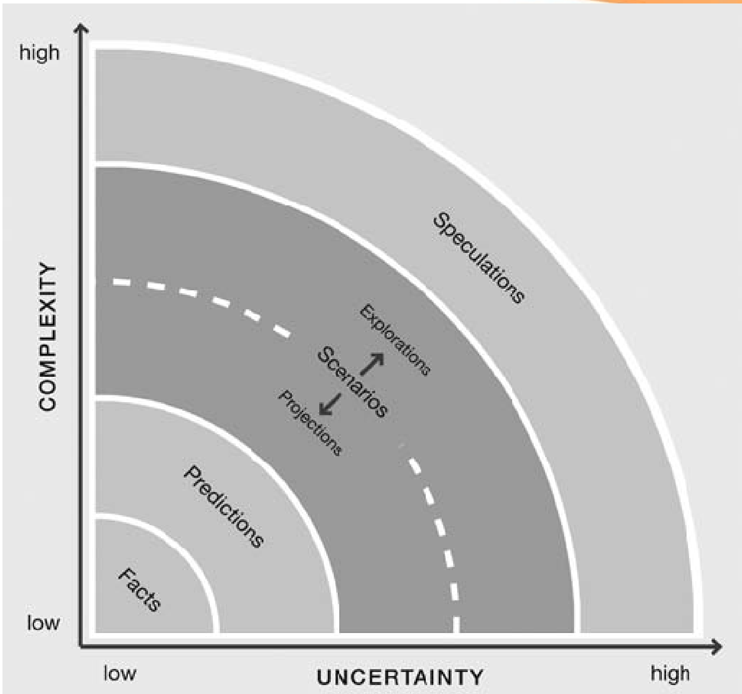
The assessment procedure

Structure

- Methodology to prepare an environmental risk assessment
  - ***Step1***: **data/information required** most of them are already provided in other parts of PRA: ecological/genetic characteristics of pest and the receiving ecosystem, human interaction
  - ***Step2***: **scenario assumptions** (SPU, temporal horizon, spatial scale, resistance/resilience, **trait-biodiversity and service clusters**)
  - ***Step3***: assessment of the **effect on biodiversity** potential consequences (on genetic, species and landscape/ecosystem diversity are assessed and scored separately)
  - ***Step4***: assessment of the **effect on ecosystem services** (SPU → modified functional traits → modified ecosystem processes → change in ES provision levels)
  - ***Step5***: **score and uncertainty** associated to the evaluation

The scenario analysis





Scenario: "…plausible and often simplified descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces, their relationships and their implications for ecosystems" (Millenium Ecosystem Assessment, 2005)

Preliminary information and assumptions for the scenario analysis

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1. **Based on the hosts and/or habitats that the pest may threaten identify the Service Providing Units (SPUs)**
    - Consider the main host plants or main functional groups in the community
    - Trophic interactions, including host-vector-pathogen relationships,
    - Competitive or cooperative interactions.

2. Define the temporal horizon

- Single or multiple time horizon
- Spread rate of the organism
- Pattern of distribution
- Rate at which impacts are likely to be observed
- invasive plants: lag phase

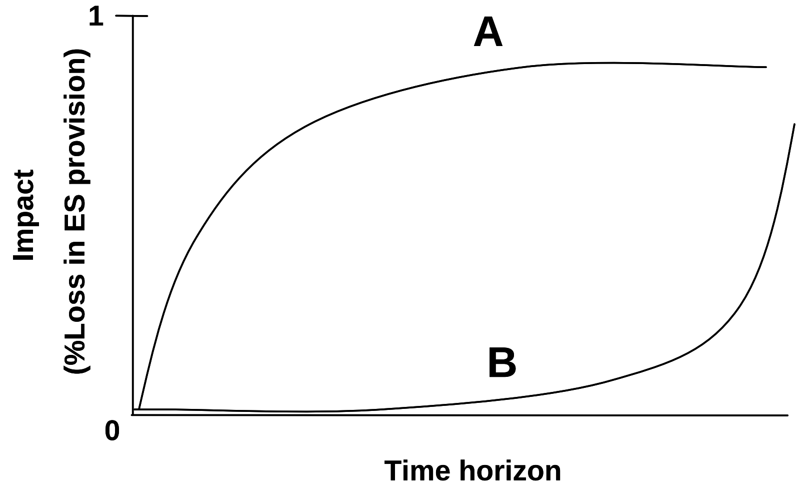
3. Define the spatial scale

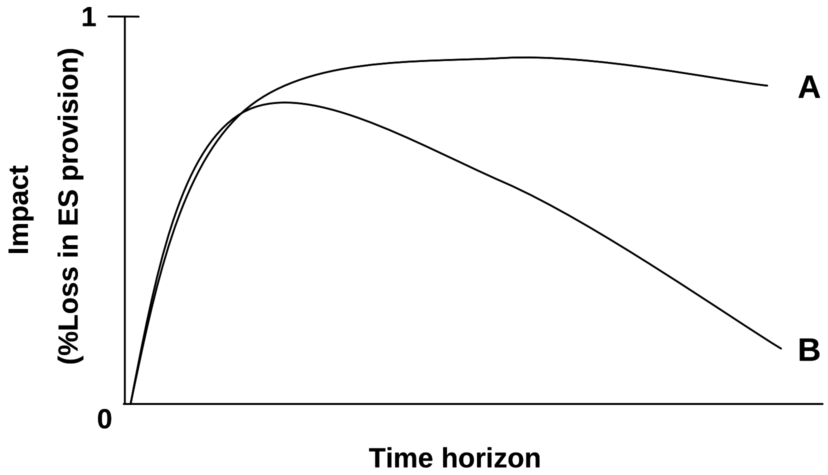
- worst case scenario according to spread and selected time frame
- how homogeneous are spread and impact?

Preliminary information and assumptions for the scenario analysis

4. Estimate the resistance and 5. the resilience of the affected SPU when the pest is present

- Consider presence of natural enemies and competitors,
- Status of the host plants or habitats or ecosystems that are affected (e.g. healthy versus weak plants, undisturbed versus disturbed habitats), including possibility that they are subject to management that may influence ecosystems' resistance and resilience





Preliminary information and assumptions for the scenario analysis

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6. List the main functional traits of the SPU affected by the pest

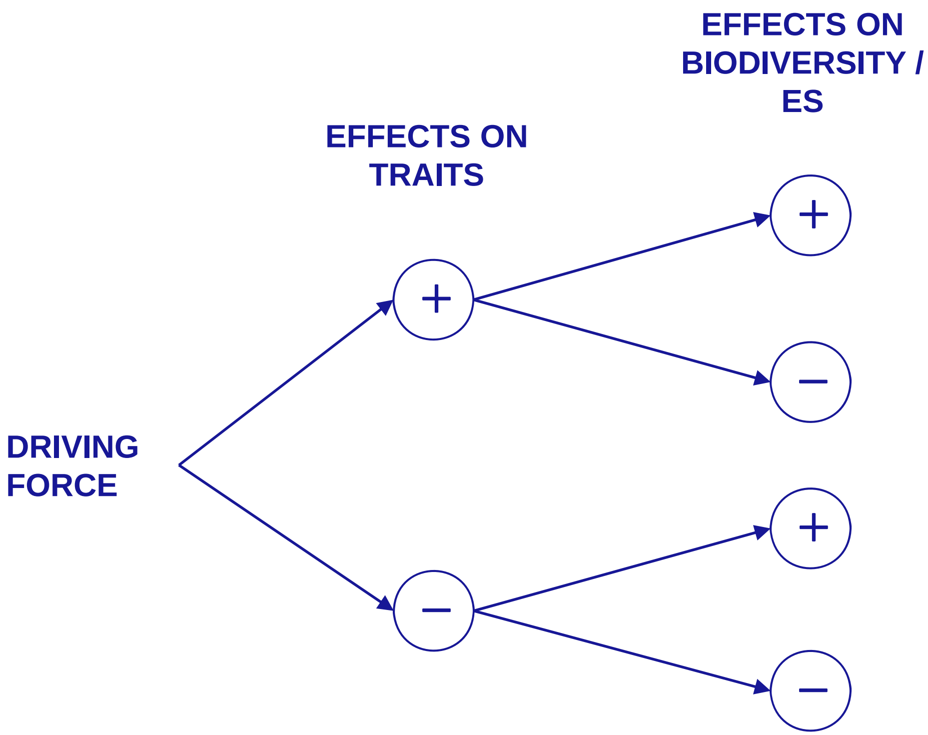
- **Functional traits at individual level**: survival, uses of the body, development, growth, reproduction, etc.

- **Functional traits at population level**: average population abundance, spatial population structure, demographic structure, strategic structure, pattern of population dynamics, etc.

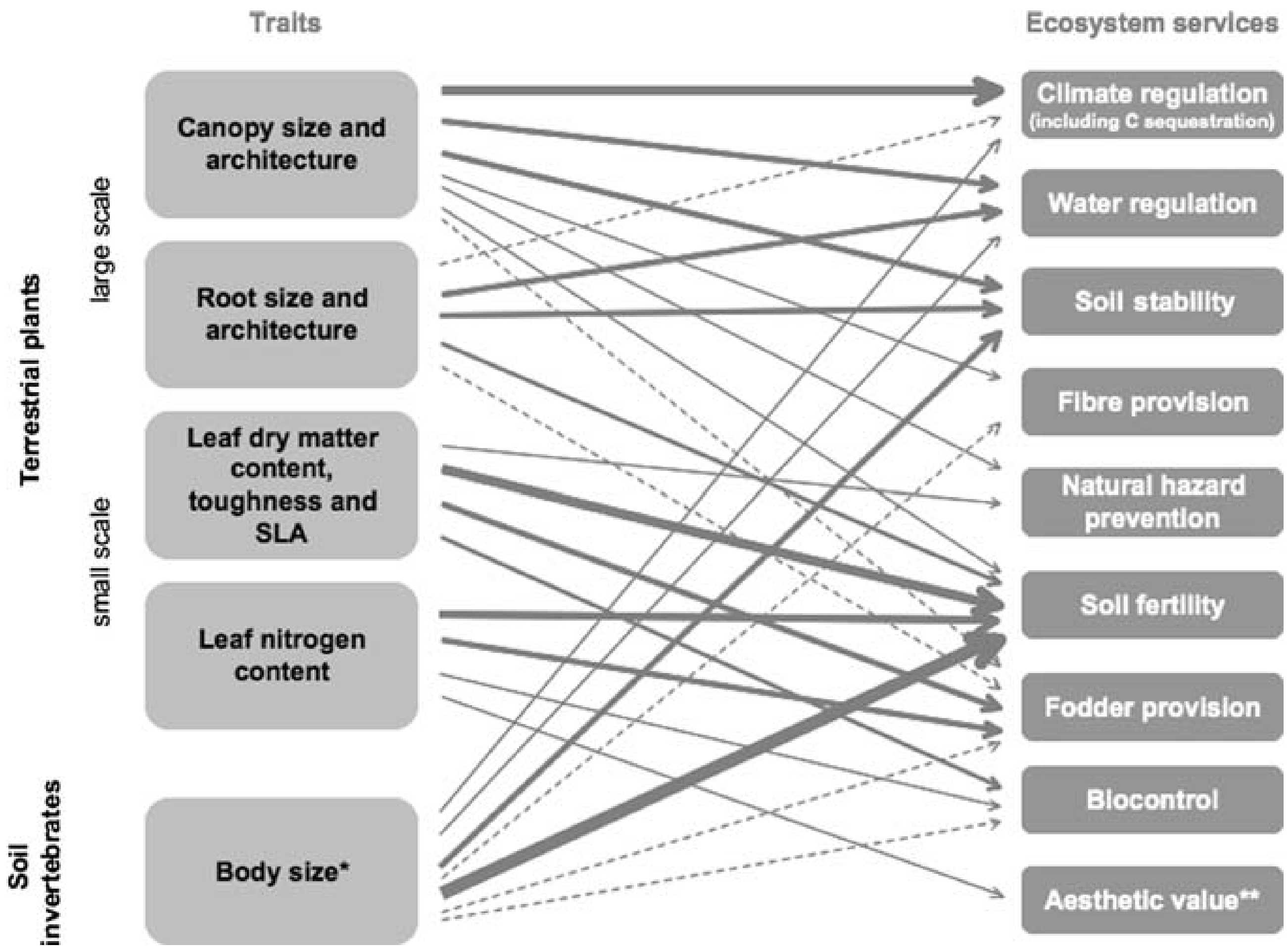
- **Functional traits at community level**: relative abundance/importance of functional groups (guilds), relative abundance/importance in dominant species, degree of functional dissimilarity in traits within the community etc.

Preliminary information and assumptions for the scenario analysis

7. Based on the list of functional traits of the SPU affected by the pest provided above (see point 6.), identify the **trait-biodiversity** and **trait-service clusters** that guide to the identification of the affected biodiversity component and ESs.



Preliminary information and assumptions for the scenario analysis

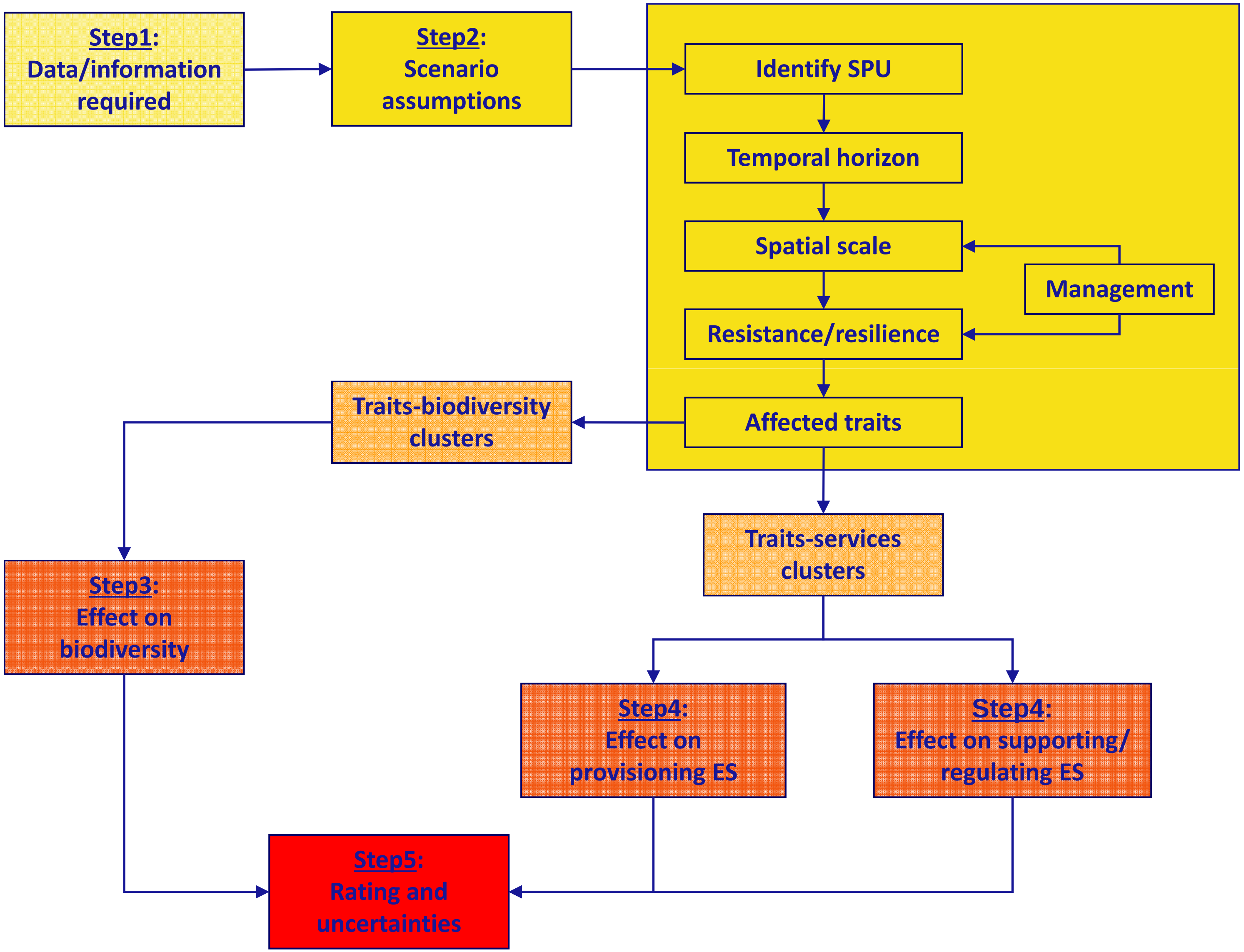


Preliminary information and assumptions for the scenario analysis

8. List the management measures that are assumed to be taken into account

- For every management measure listed, explain whether it changes the pattern of impact or not.
- Take into account
  - The feasibility of containment and/or eradication,
  - The effect on the intensity of the impact of the pest,
  - The effect on resistance and/or resilience of the invaded area

A flow chart of the procedure



List of questions

- Structural Biodiversity
  - **Q.3.2.1.:** To what extent is **genetic diversity** likely to increase or decrease as a result of invasion?
  - **Q.3.2.2.:** To what extent are there any **rare or vulnerable species** among the native species expected to be affected as a result of invasion?
  - **Q.3.2.3.:** To what extent is there a possible **decline in native species** as a result of the invasion?
  - **Q.3.2.4.:** To what extent is there an expected impact on objects or **habitats of high conservation value** as a result of invasion?
  - **Q.3.2.5.:** To what extent are changes likely in the composition and **structure of native habitats, communities and/or ecosystems** as a result of invasion?

List of questions

Rating	*Explanation*
Minor	Changes in genetic diversity have not been appreciable. None of the above-mentioned population genetic effects have been observed. Alien species without taxonomically very closely related species (sub-species or congeneric) or with no record of cross-breeding with other species will fall into this category.
Moderate	Changes in genetic diversity (specify if - or +) have been appreciable One or two of the above-mentioned population genetic effects have been observed, but expression of the effect(s) is not strong. Examples: Hybridization between alien and native bumble bee, *Bombus* spp. (Hymenoptera: Apidae) is obtained in the laboratory, but their offspring is usually sterile. In Japan, fertile hybridization is obtained in the lab between the native parasitoid *Torymus beneficus* and the alien *T. sinensis* (Chalcidoidea: Torymidae), but studies showed that hybridization in the field was marginal.
Major	Changes in genetic diversity have been substantial (specify if – or +) Several of the above-mentioned population genetic effects have been observed, at

List of questions

- Ecosystem services provision level
  - **Q.5.1.:** How great is the magnitude of reduction in the **provisioning services** affected in the risk assessment area?
  - **Q.5.2.:** How great is the magnitude of the reduction in the **regulating and supporting** services affected in the risk assessment area?

List of questions

ECOSYSTEM SERVICES	MAGNITUDE CLASS	REDUCTION IN ECOSYSTEM SERVICES PROVISION LEVEL	PROBABILITY OF OCCURRENCE
Q.4.3.1. *Air quality regulation*	1. Minimal	Zero or negligible	
	2. Minor	0<M=5 %	
	3. Moderate	5<M=20 %	
	4. Major	20<M=50 %	
	5. Massive	M>50 %	
Q.4.3.2. *Climate regulation*	1. Minimal	Zero or negligible	
	2. Minor	0<M=5 %	
	3. Moderate	5<M=20 %	
	4. Major	20<M=50 %	
	5. Massive	M>50 %	
Q.4.3.3. *Water regulation, cycling and purification*	1. Minimal	Zero or negligible	
	2. Minor	0<M=5 %	
	3. Moderate	5<M=20 %	
	4. Major	20<M=50 %	
	5. Massive	M>50 %	
Q.4.3.4. *Erosion regulation*	1. Minimal	Zero or negligible	
	2. Minor	0<M=5 %	
	3. Moderate	5<M=20 %	
	4. Major	20<M=50 %	
	5. Massive	M>50 %	
Q.4.3.5. *Soil formation and nutrient cycling*	1. Minimal	Zero or negligible	
	2. Minor	0<M=5 %	
	3. Moderate	5<M=20 %	
	4. Major	20<M=50 %	
	5. Massive	M>50 %	
Q.4.3.6. *Photosynthesis and primary production*	1. Minimal	Zero or negligible	
	2. Minor	0<M=5 %	
	3. Moderate	5<M=20 %	
	4. Major	20<M=50 %	
	5. Massive	M>50 %	
Q.4.3.7. *Pest and disease regulation*	1. Minimal	Zero or negligible	
	2. Minor	0<M=5 %	
	3. Moderate	5<M=20 %	
	4. Major	20<M=50 %	
	5. Massive	M>50 %	
Q.4.3.8. *Pollination*	1. Minimal	Zero or negligible	
	2. Minor	0<M=5 %	
	3. Moderate	5<M=20 %	
	4. Major	20<M=50 %	
	5. Massive	M>50 %	

The rating system

- Rating system
  - Based on a **probabilistic approach**
  - Ensures **consistency and transparency** of the assessment
  - Makes it possible to **evaluate the level of risk** and the associated uncertainty for every Sub-Question and then the overall risk and uncertainty for every Question
  - A method for the quantification of the **degree of uncertainty** has been developed (results are categorised)

The rating system

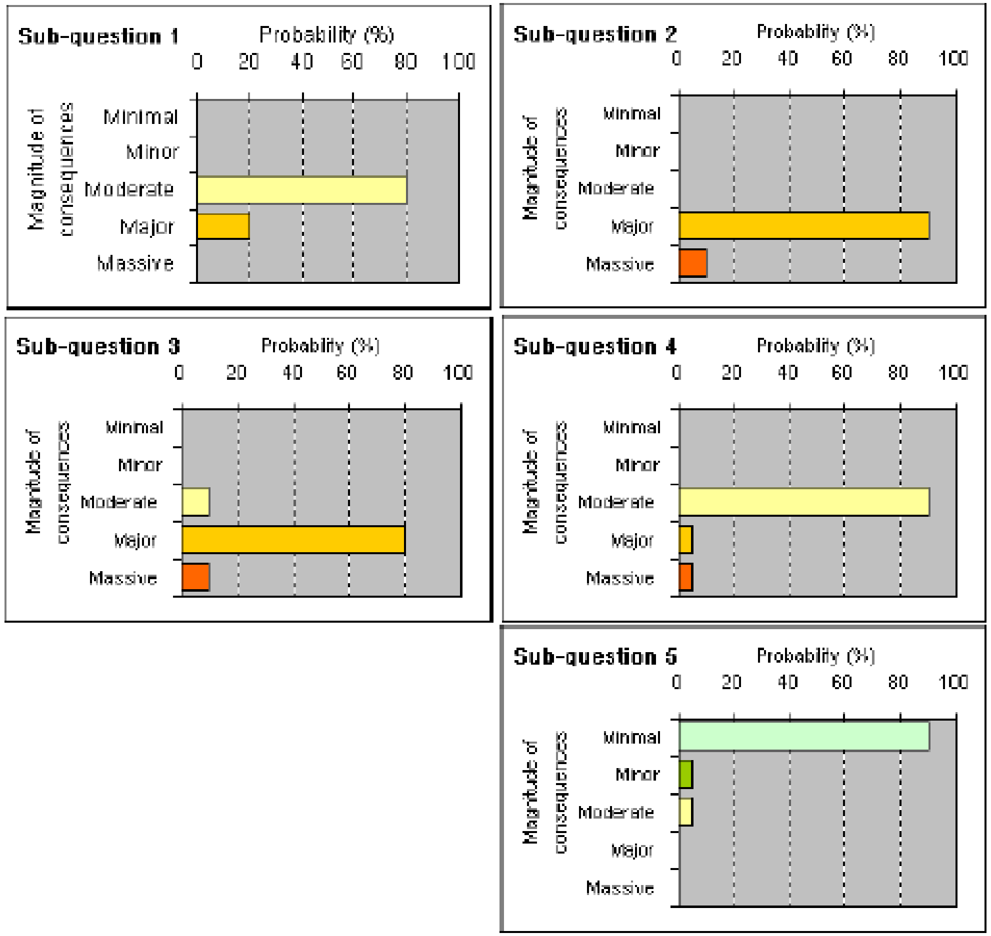


Figure 11: Graphical representation of the probability distributions of Table 7, step 2.

The rating system

Table 4: Example of possible probability distributions of the magnitude of consequences, *L*, for each *i*-th Sub-question of any *k*-th Question. The set of the values $P(L=j)$, represents the probability distribution of the categorical variable *L*.

Sub-question (hazard, H_i)	Magnitude of consequences L_i			
	Minor $j = 1$	**Moderate** $j = 2$	**Major** $j = 3$	
	Probability of occurrence, $P(L_i = j)$ (%)			Check sum
$i = 1$	20	50	30	100
$i = 2$	10	80	10	100
$i = 3$	0	20	80	100
$i = 4$	60	30	10	100
$i = 5$	30	40	30	100

Table 6: Scoring system for the assessment of magnitude of consequences (term *L* in the formula [2]), in %, using 5 ratings ($J = 5$), and examples of possible intervals and mid points of the ratings.

Rating (j)	Magnitude of consequences, in % (L)	Midpoint of the rating, in % (L^*)
Minimal	Zero or negligible	0
Minor	$0 < L \leq 5$ %	2.5
Moderate	$5 < L \leq 20$ %	12.5
Major	$20 < L \leq 50$ %	35
Massive	$L > 50$ %	75

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Recommendations and concluding remarks

- The EFSA approach on the environmental risk of plant pest
  - Based on a **consistent and comprehensive framework** of analysis
  - **Provides a solution** to the problems related to **appropriate level** (individual, population, community) and type of analysis (trophic interactions, energetics, biogeochemical cycles, succession)
  - Proposes a scientific **interpretation of the interface** between natural processes and the way in which humans operate within the ecosystems
  - Addresses the need to consider **autonomous properties and values** related to nature (the consideration of the structural biodiversity)
  - Allows to define an **integrated assessment** and also **quantify** (also in economic terms – in the future) the impact on the environment

- The EFSA-PLH recognises that assessing environmental impacts on the basis of the ecosystem services concept is **a developing area**
  - The approach has been **tested on some case-studies** (e.g. *Anoplophora chinensis*)
  - We **expect methodological developments** and more precise and articulate schemes and quantification methods to emerge as experience accumulates
  - Results of horizontal harmonisation **activities within EFSA**
  - Any relevant **new information** which may have an impact on the current opinion, e.g. further developments in the ES concept and its application

- Further work is recommended, e.g.
  - **Using the scheme** for species with a wide range of environmental impacts (*Pomacea* spp. self task)
  - **Comparing this approach** with that used in other schemes from the perspective of the risk assessor, risk manager and risk modellers
  - To explore possibility to use **quantitative assessment** (percentages) to describe levels of impact on **biodiversity**
  - To explore potentiality of the **scenario exercise** (leading to a set of assumptions) for the entire PRA

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http://www.efsa.europa.eu/en/efsajournal/pub/2460.htm

Thank you for your attention!

For more info on the EFSA Scientific Panel on Plant Health:
http://www.efsa.europa.eu/en/panels/plh.htm