



SIGMEA

Sustainable introduction of GM crops into
European Agriculture

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FP6 – 2004-2007



SIGMEA partnership

- 44 partners from 12 European countries;
- **Principal programmes studying crop-to-crop gene flow** over a wide number of countries across Europe with a diversity of agricultural systems including organic and landrace cropping;
- Links with existing (FP5) or forthcoming research projects;
- International co-operation (North-America, Australia)



Background

- Reinforcement of Environmental Risk Assessment (Dir. 2001/18)
 - Interactions between GMOs
 - Indirect and long-term effects should be addressed
- Issue of co-existence: « farmers should be able to cultivate freely the crops they choose »

→ A real challenge for science and for regulation



Background

- A large amount of information is available on direct effects of GMOs but remains fragmented;
- Indirect and long-term effects highly depend on regional environments, local landscapes, farming systems and practices;

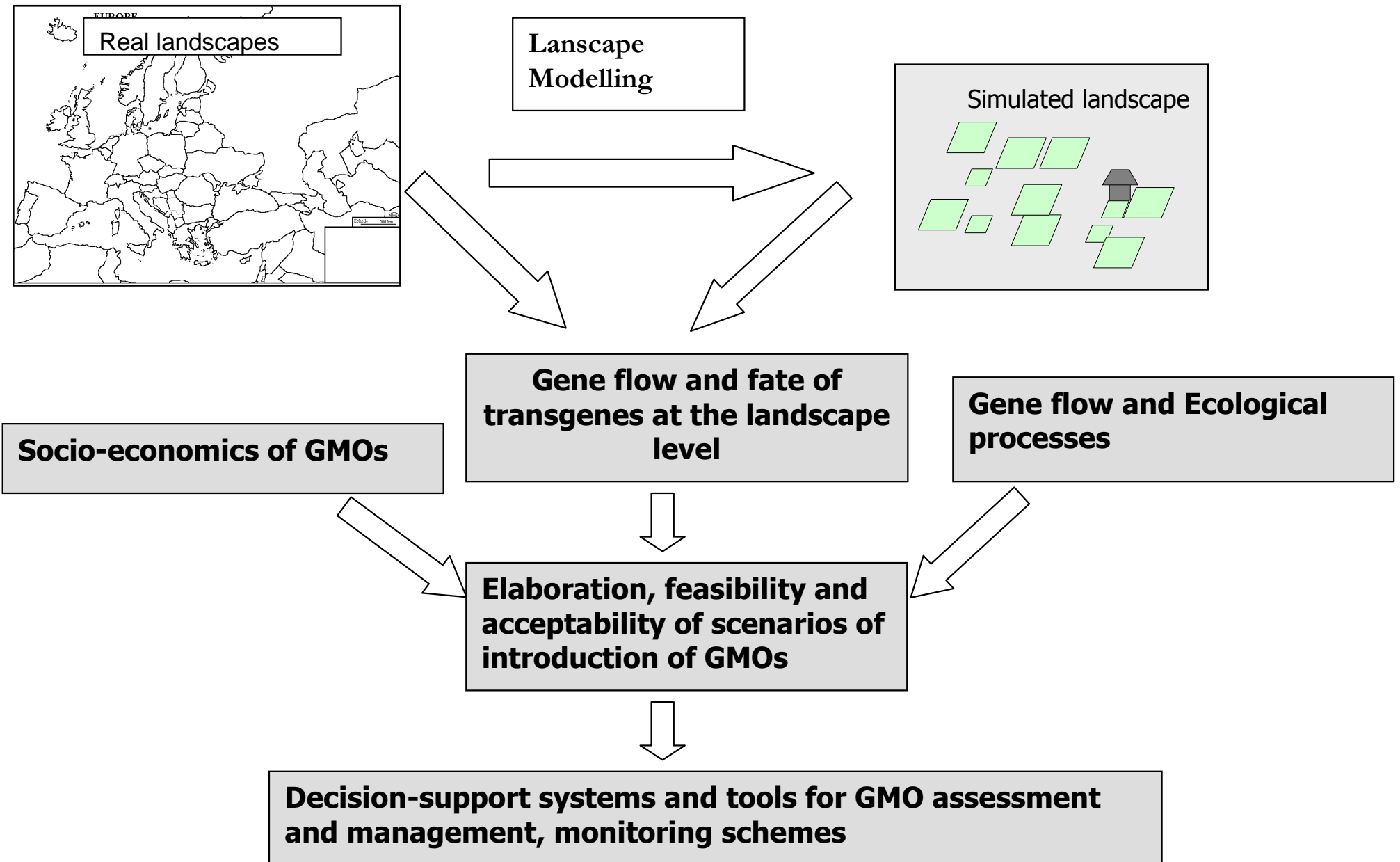
→ Field experiments are necessary but not sufficient
→ Modelling is a key issue for taking into account the various factors.



General objective of SIGMEA

To set up a science-based framework, strategies, methods and a practical toolbox for:

- Assessing ecological and economical impacts of GM crops at the landscape level;
- Designing management rules and scenarios;
- Implementing monitoring schemes.





SIGMEA Objectives

- **To collate and synthesize existing and developing experimental information on gene flow** of the major GM crops targeted for this study (oilseed rape, maize) as well as for other crops considered: sugar beet, rice and wheat;
- **To conduct landscape scale evaluations of gene flow and develop bio-geographical models of outcrossing, seed dispersal and persistence covering whole farms and regional scales** for beet, maize and oilseed rape;
- **To design a landscape generator simulating agricultural landscapes** (field patterns, cropping systems allocation) from statistical descriptors.
- **To design and implement an operational, practical and dynamic generic gene flow modeling platform at the landscape level.**



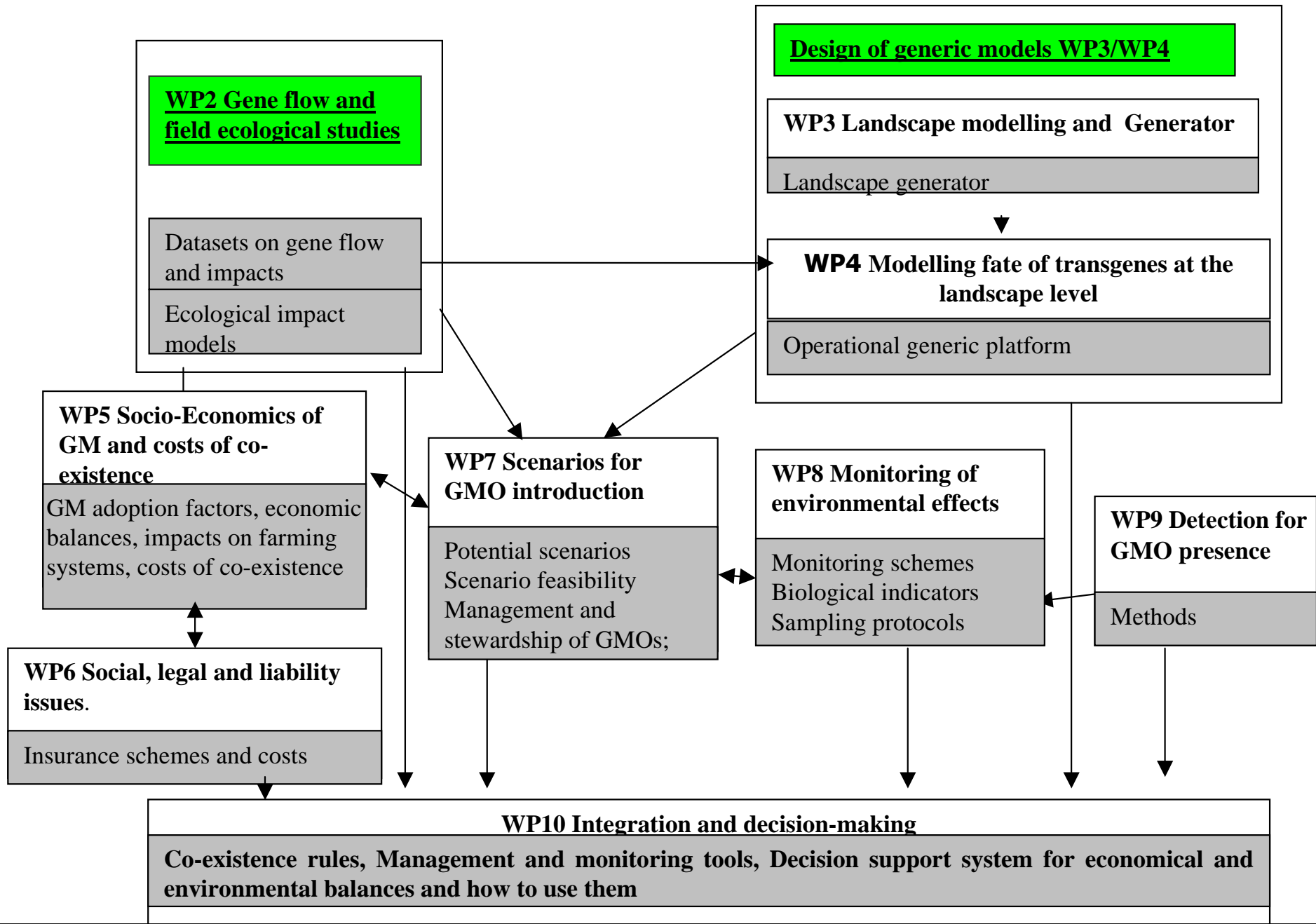
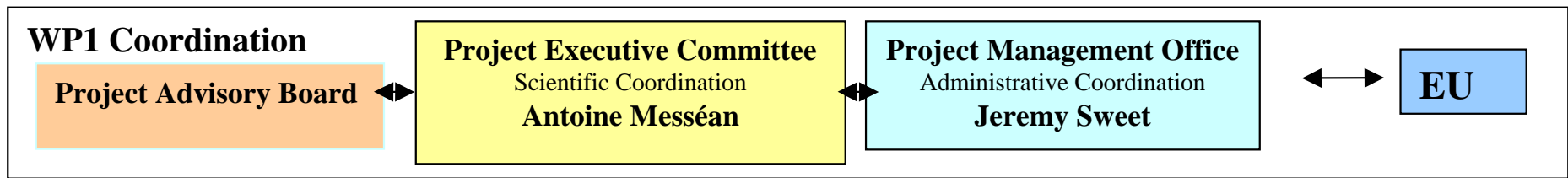
SIGMEA Objectives

- **To identify changes in farming practices that minimize gene flow and adventitious mixing of GM and non-GM crops** and the feasibility of applying these measures on the farm;
- **To propose various scenarios, ensuring co-existence in six regional case studies** and evaluate their technical feasibility, economical costs and acceptability by local operators.
- **To determine socio-economic and environmental impacts coming from the adoption or not of GM crops** by the farmers.
- **To build up an integrated and dynamic decision-support system for assessing the sustainability of regional farming systems** taking into account both ecological and economical aspects.

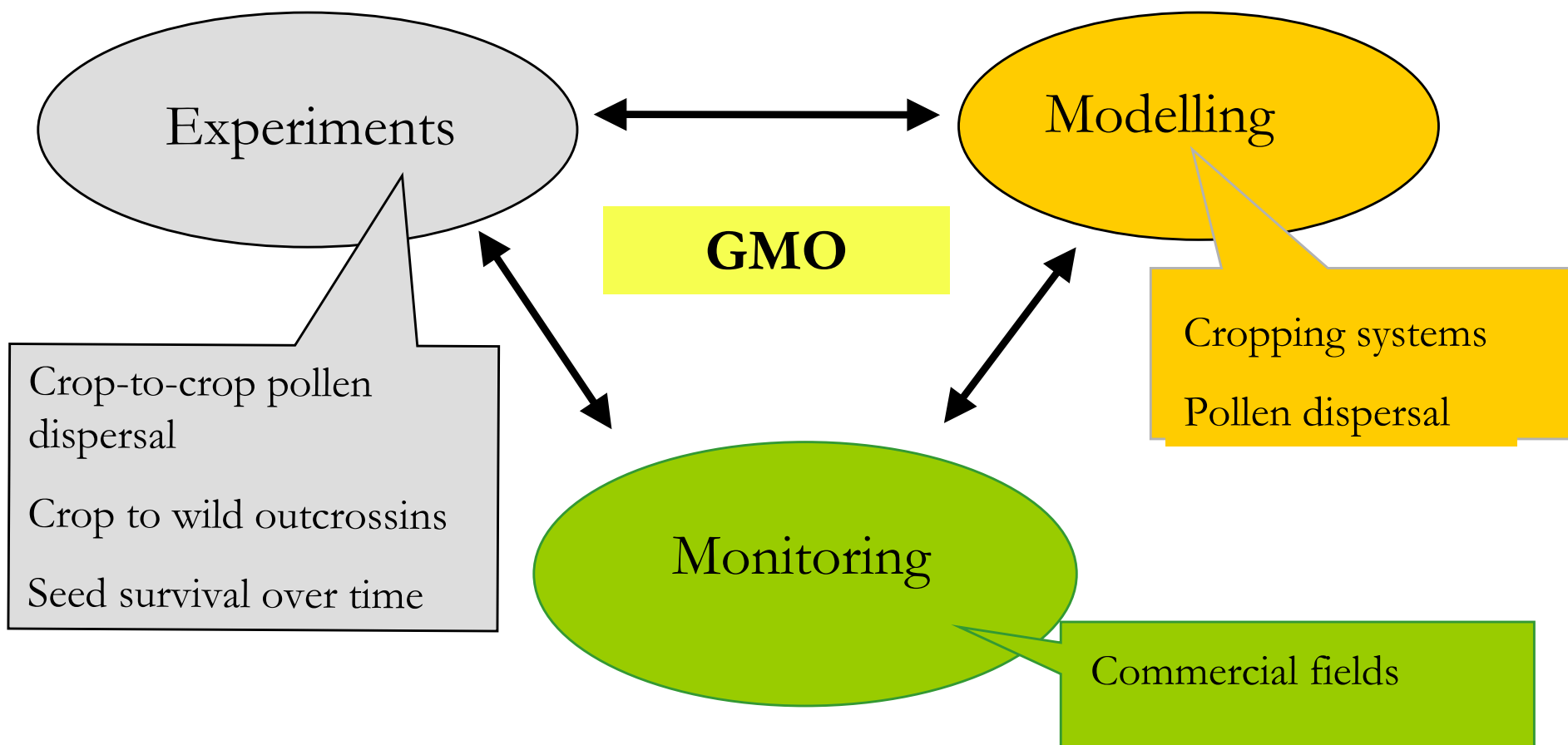


SIGMEA Objectives

- **To provide practical recommendations for the decision-making processes relating to the market release of GM crops under progress.**
- **To design on-site novel methods for GMO detection, identification and quantification as well as sampling procedures for maize, oilseed rape and sugar beet;**
- **To provide a long-term monitoring strategy for EU including recommendations for regulation, relevant biological indicators, sampling and detection methods and analyze its economical implications;**
- **To analyze the current regulatory regimes of EU and member states, their implementation as well as the interest and practice of insurance and re-insurance companies related to liability issues on the release of GMOs.**



Modelling is a key approach





The coexistence issue

- “Farmers should be able to cultivate freely the agricultural crops they choose, be it GM, conventional or organic” (Recommendation 2003/556/EC)
- Coexistence between supply chains already exists
 - Sweet maize/waxy maize
 - Seed production
- But new issues raised with GMOs
 - Identical nature and markets
 - Mass production rather than specialty production
 - Lower thresholds



Why models are necessary

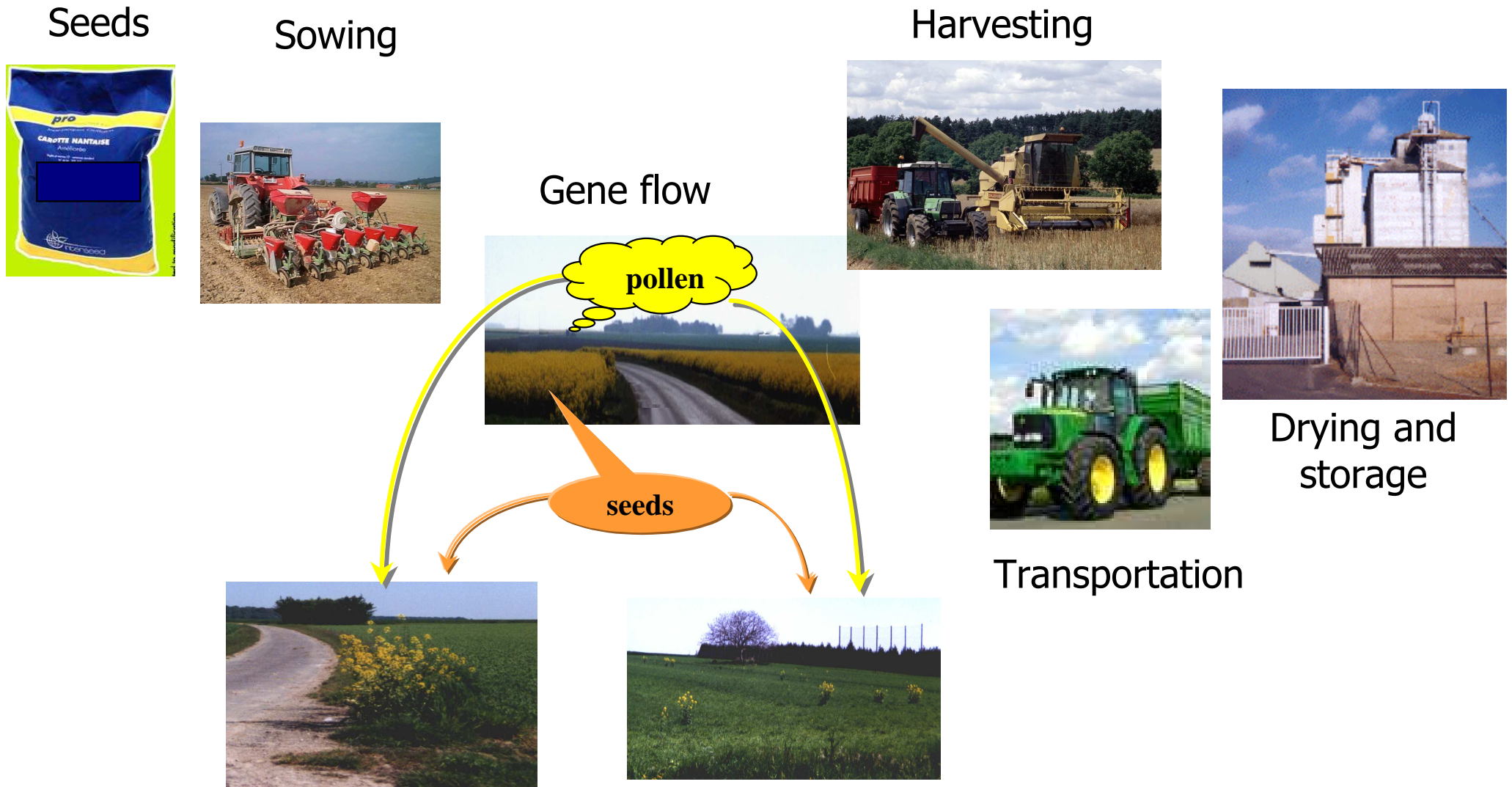
- The landscape fragmentation and farmer practices have a great influence on gene flow and adventitious presence
 - Many factors and interactions to be addressed on a long-term basis, e.g., crop rotations, seed spillage, effect of soil tillage
 - Field studies no longer sufficient
 - Different decision levels should be taken into account:
 - Farm level: What if I grow GM in this field? How to grow it?
 - Local level: How to organize spatial allocation between farms?
 - Regional level: What coexistence measures would ensure coexistence whatever the farming system?
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What models can do

- Structuring knowledge, identifying gaps and reducing research fragmentation;
 - Ranking farming systems according to adventitious presence in non-GM production;
 - Forecasting the behaviour of transgenes in cultivated and non-cultivated lands;
 - Testing *a priori* the efficiency of coexistence measures or regulation schemes;
 - Implementing monitoring schemes by identifying high risk situations;
 - Re-assessing the overall balance of the impacts of GM crops.
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Sources of adventitious presence



Coexistence in maize crop production

Poitou-Charentes, France





Field pattern

Sowing date
and density

Maize
varieties

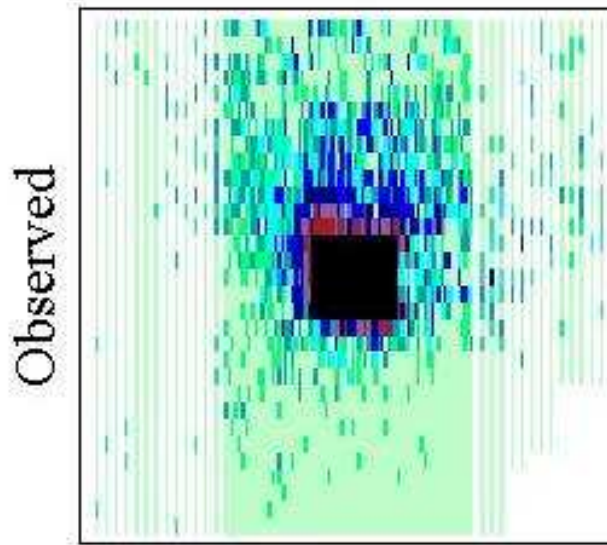
Climate

MAPOD

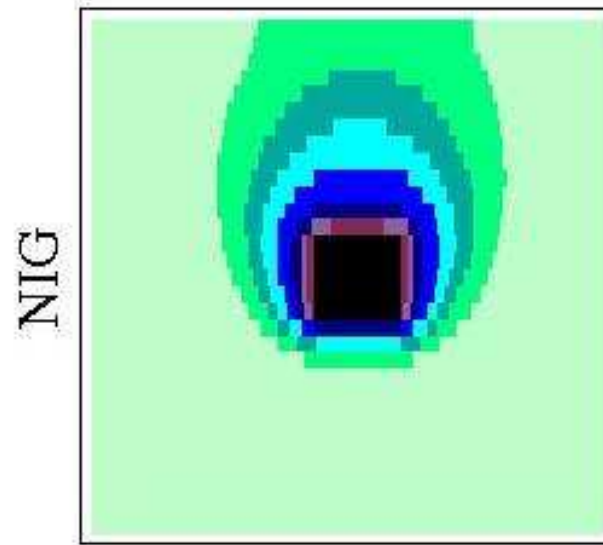
For each non – GM plant in each field: number of
grains with the transgene

Proportion of GM grains in
non OGM harvest

Maize dispersal curve



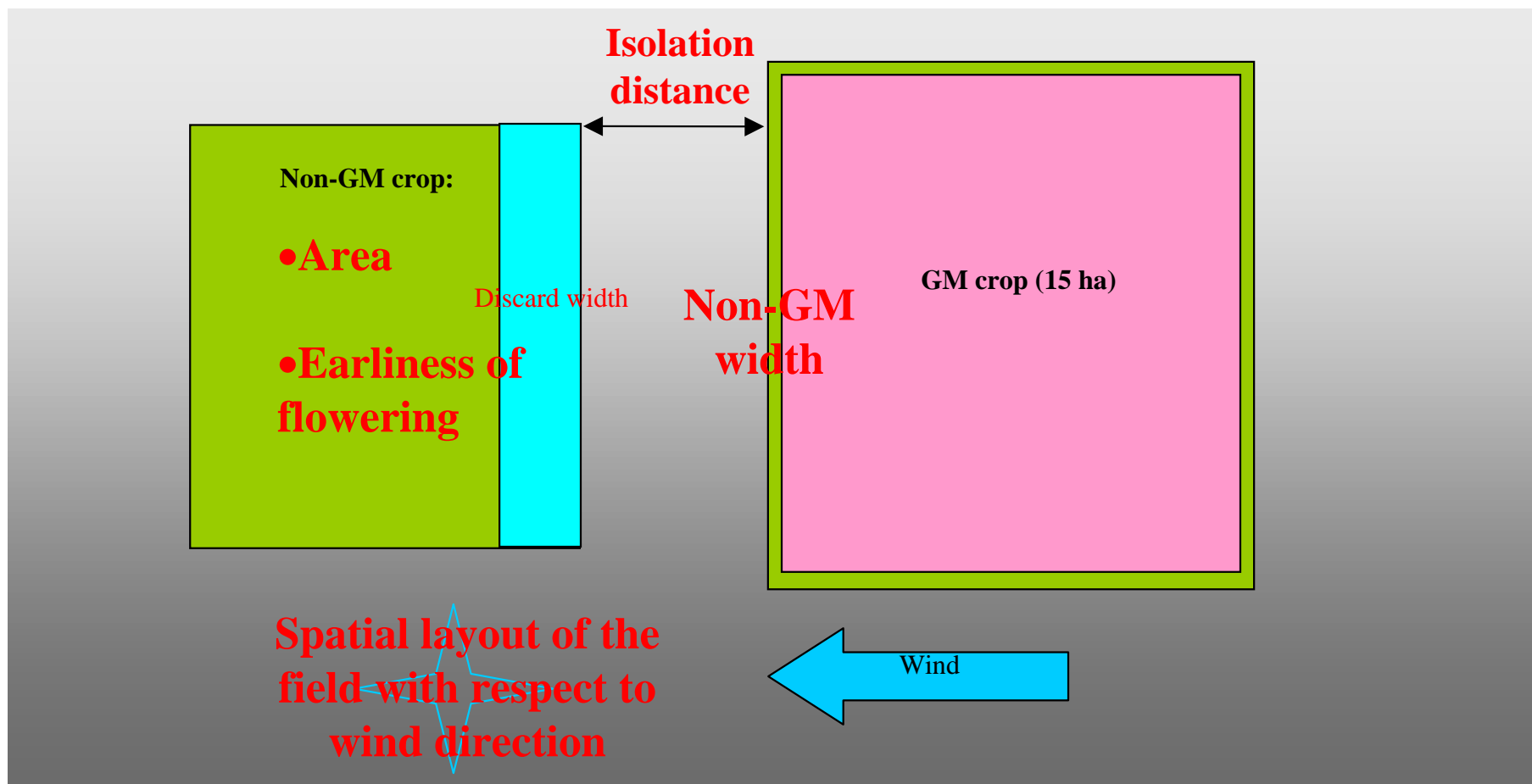
(Montargis, 1998)



(Klein, 2000)

→ On-going validation under various contexts

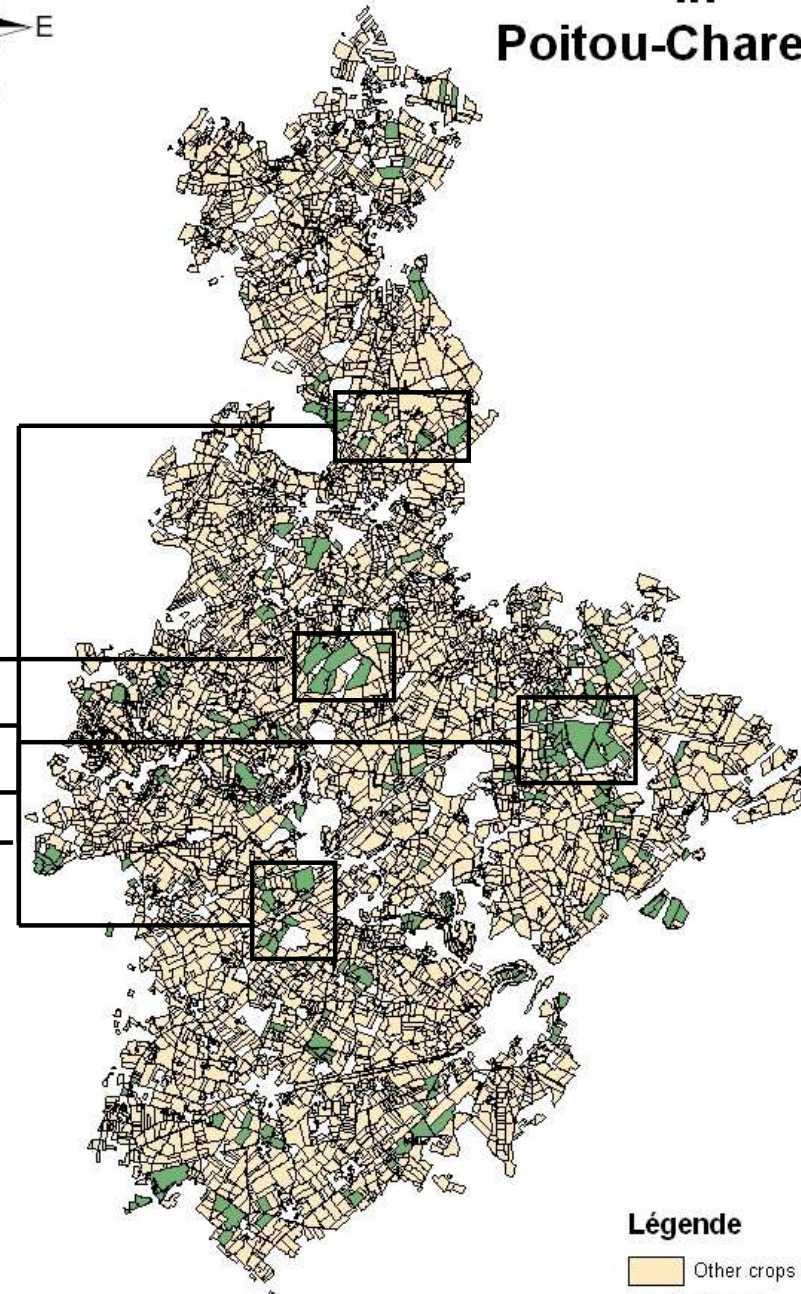
Measuring gene flow at field scale



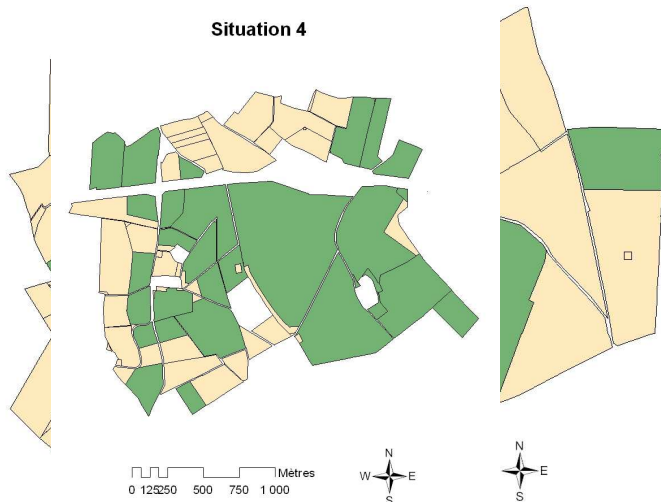
- An cluster organisation: maize plots are grouped around water supply points
- Each cluster differs from the others by:
 - Its area which depends on the number and the area of the fields in the cluster
 - The number of farmers who owns one or many fields in the cluster
- We have considered four clusters

Situation	Number of clusters	Mean area of clusters (ha)	Mean number of fields by cluster	Mean number of farmers by cluster	Mean distance between clusters (m)
1	6	11	1,5	1	390
2	3	33	4	2,33	385
3	4	37	2	1,25	260
4	1	240	29	6	XXX

Study region in Poitou-Charentes



Situation 4



Légende

- Other crops
- CODECULT
- Maize

0 1 250 500 7 500 10 000 Mètres



How to set up coexistence measures

- Statistical approach
 - Analyze a wide range of gene flow experiments covering the variability of factors;
 - Determine adequate isolation distances depending on crops and regional environment under the worst case-scenario;
 - Adapted to National or regional measures and pollen-mediated gene flow crops
- Mechanistic approach
 - Modelling the effects of landscapes, climate and agricultural practices
 - Necessary for farm-scale decision-making and crops with seed-mediated gene flow



A generic and dynamic framework

- Genericity:
 - Several crops : maize, rapeseed, beet, rice, wheat, etc
 - Several applications: co-existence, environmental assessment, monitoring;
 - Various decision levels: regulation bodies, operators
- Dynamics:
 - Improvement of models;
 - Involvement of users;
 - Re-assessment from post-marketing monitoring.



Conclusions

- Compatibility between kernels and DNA based contents remains to be taken into account into predictive models
- Gene flow datasets to be collated, structured and analyzed
- Models are necessary for addressing the diversity of cropping systems and practices, the diversity of decision-making situations and designin monitoring schemes
- Models are a dialogue tool with decision-makers and stakeholders;
- Most of the results and models are useful for « conventional » coexistence issues;
- Analysis of post-farm supply chains: identification of critical points and modelling
 - FP6 Co-Extra Integrated project