Utilisation de données *Google Street View* pour cartographier la processionnaire du pin

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Journées Payote / Modelia « Deep learning, télédétecttion et paysage », Paris, 27/06/2019

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… et de nouveaux outils de *monitoring* pour suivre sa phénologie à distance

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La processionnaire du pin : enjeux de santé végétale, animale et humaine

La processionnaire du pin, *Thaumetopoea pityocampa*

chenilles défoliatrices

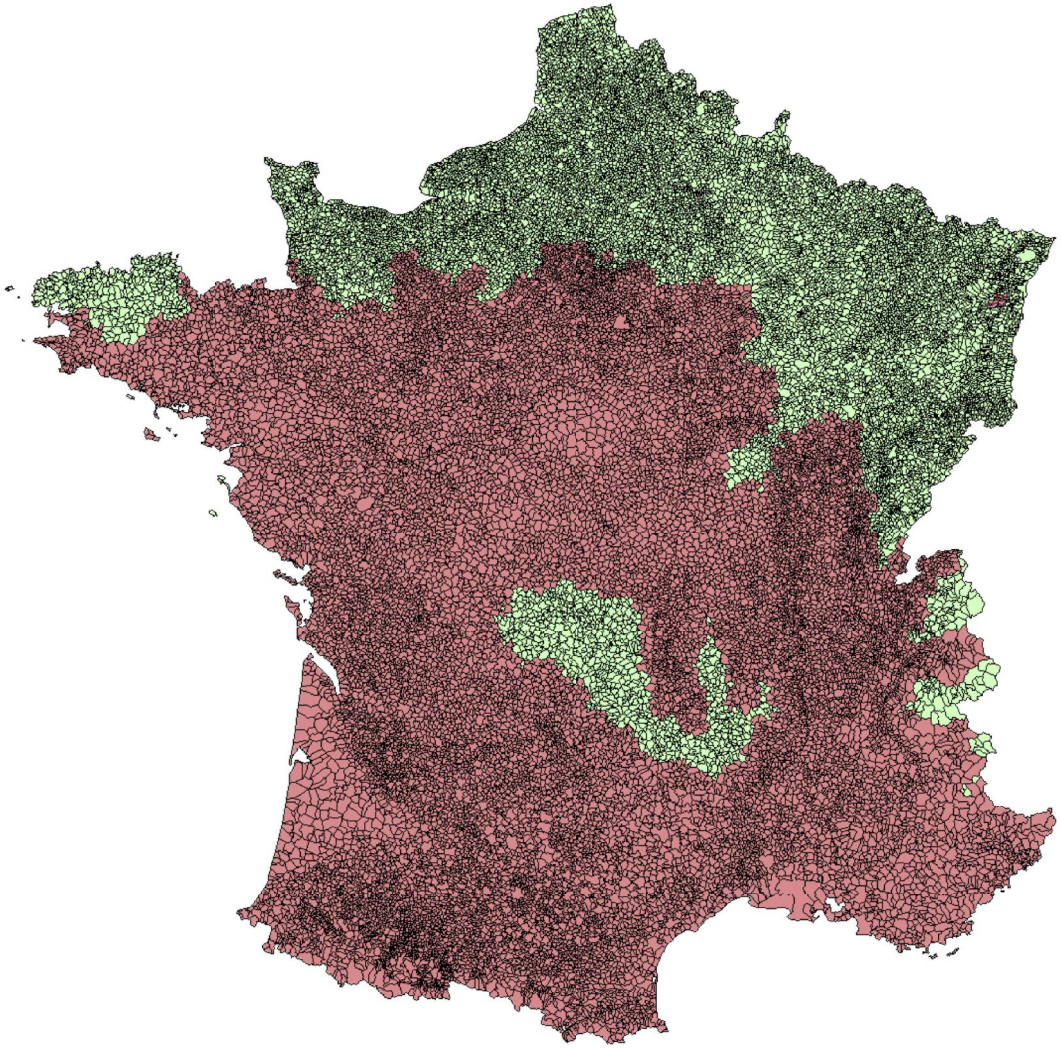
chenilles urticantes

Photos : Rousselet, Démolin, Martin, Roques, ANSES, Barral, Battisti

La processionnaire du pin : enjeux de santé végétale, animale et humaine

Collectivités territoriales concernées par la processionnaire du pin

- ⇨ ~ 21 000 communes / 36 000
- ⇨ 84 départements / 96
- ⇨ 13 régions / 13



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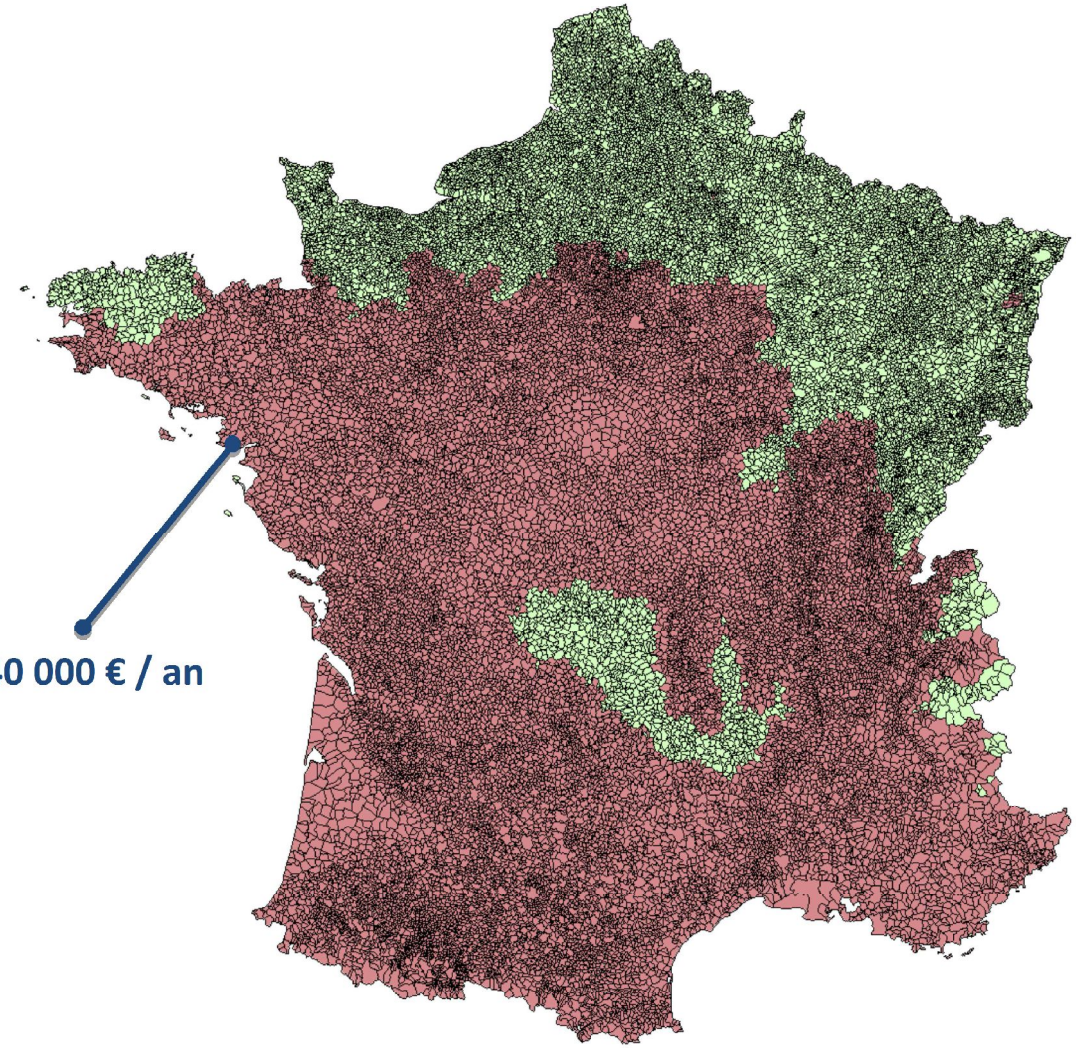
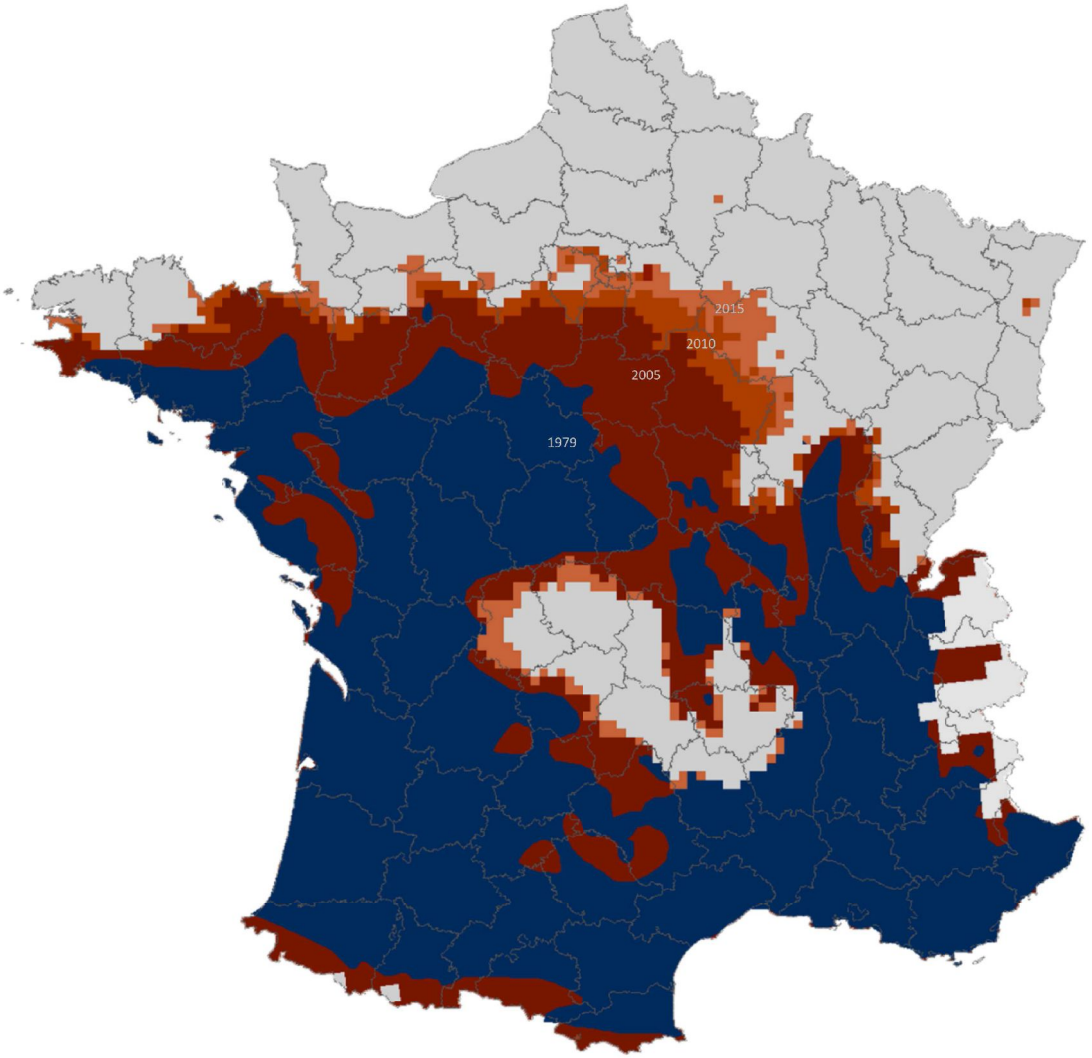


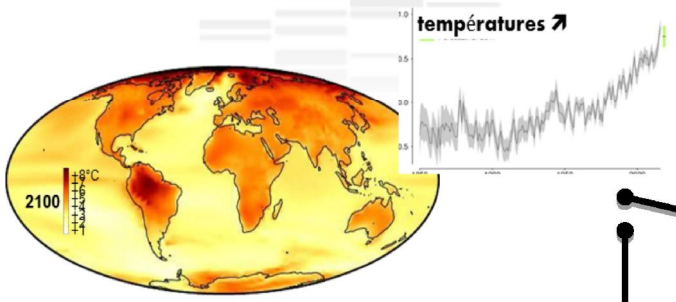
La processionnaire du pin : enjeux de santé végétale, animale et humaine

Une espèce en expansion depuis les années 1990 sous l'effet du réchauffement climatique

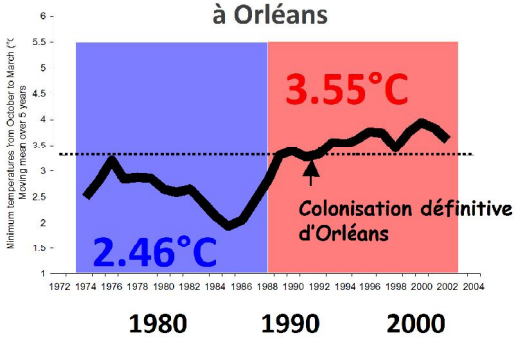


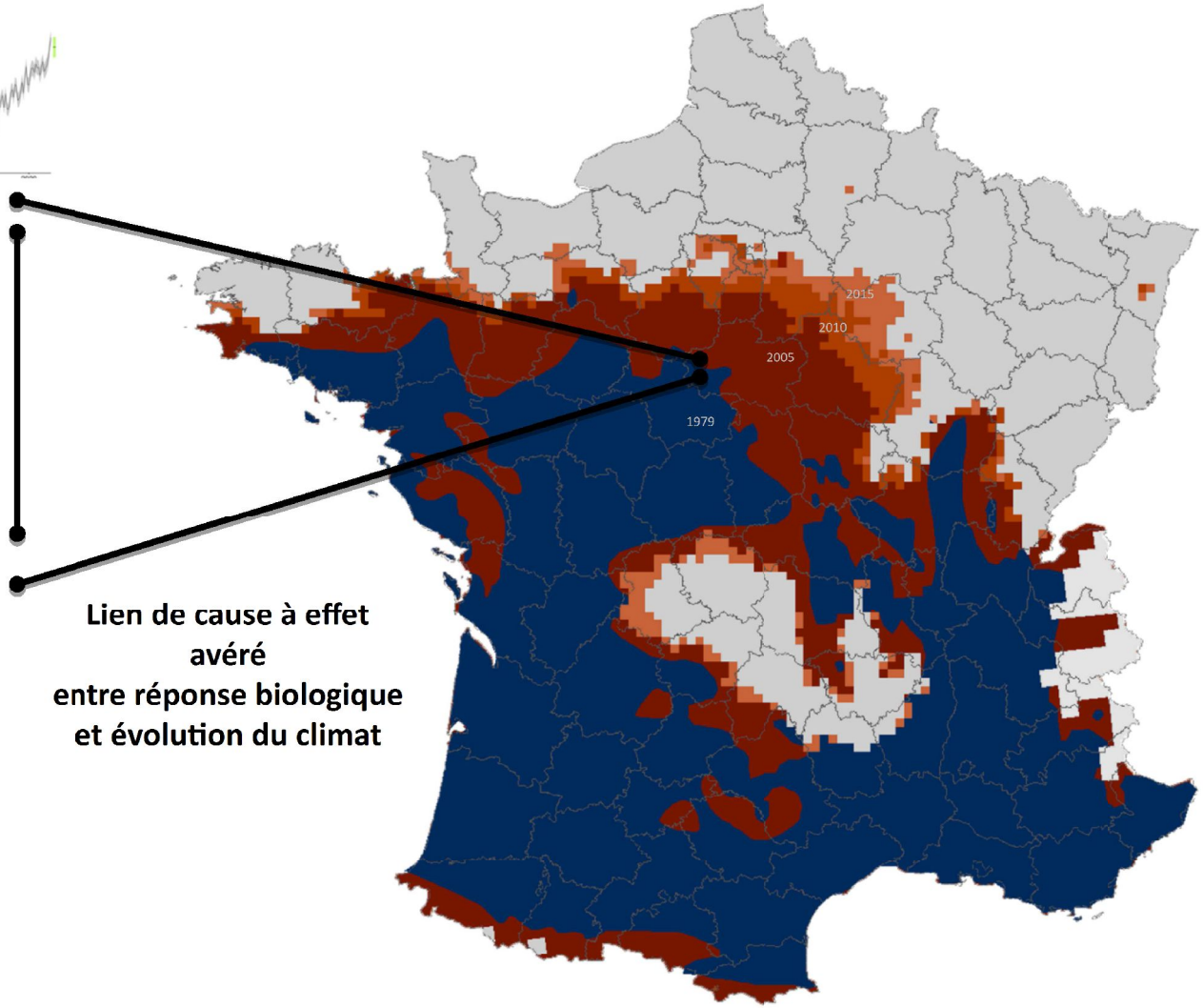
La processionnaire du pin, *Thaumetopoea pityocampa*

Processionnaire du pin et réchauffement climatique



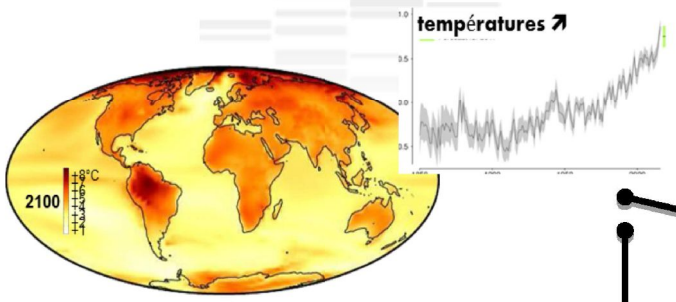
Augmentation des températures hivernales à Orléans





Lien de cause à effet avéré entre réponse biologique et évolution du climat

Processionnaire du pin et réchauffement climatique



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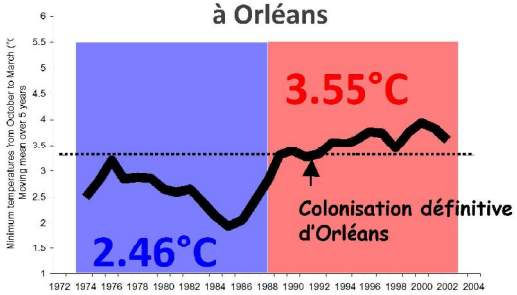
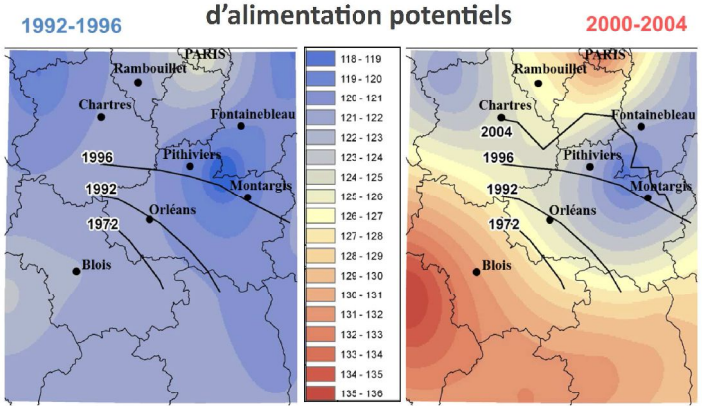
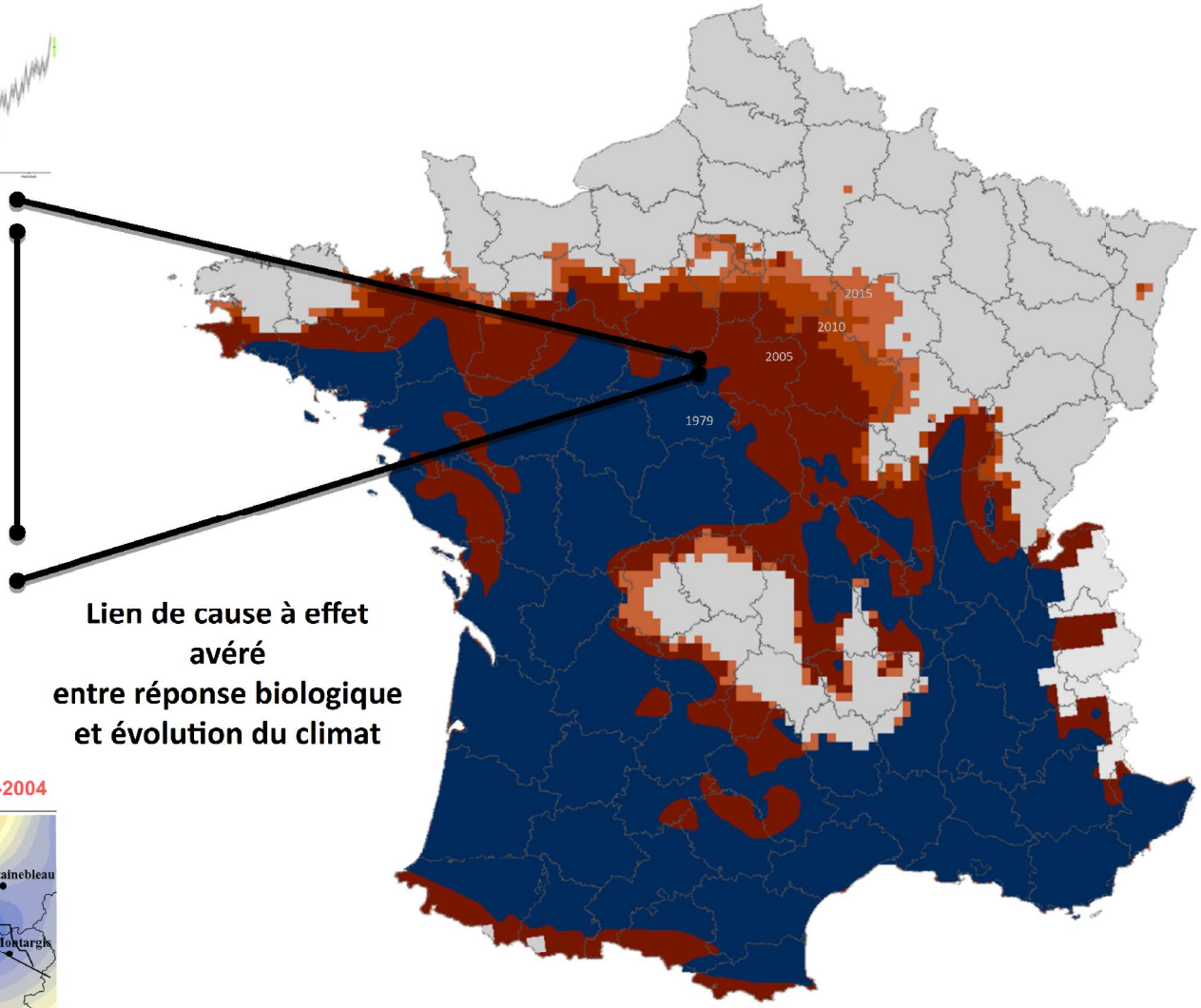


nombre de jours d'alimentation potentiels





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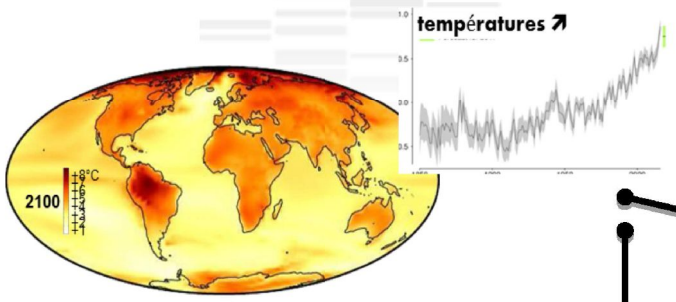

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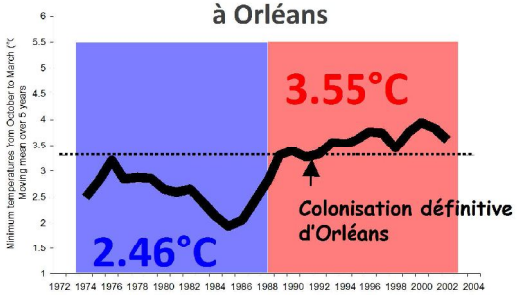

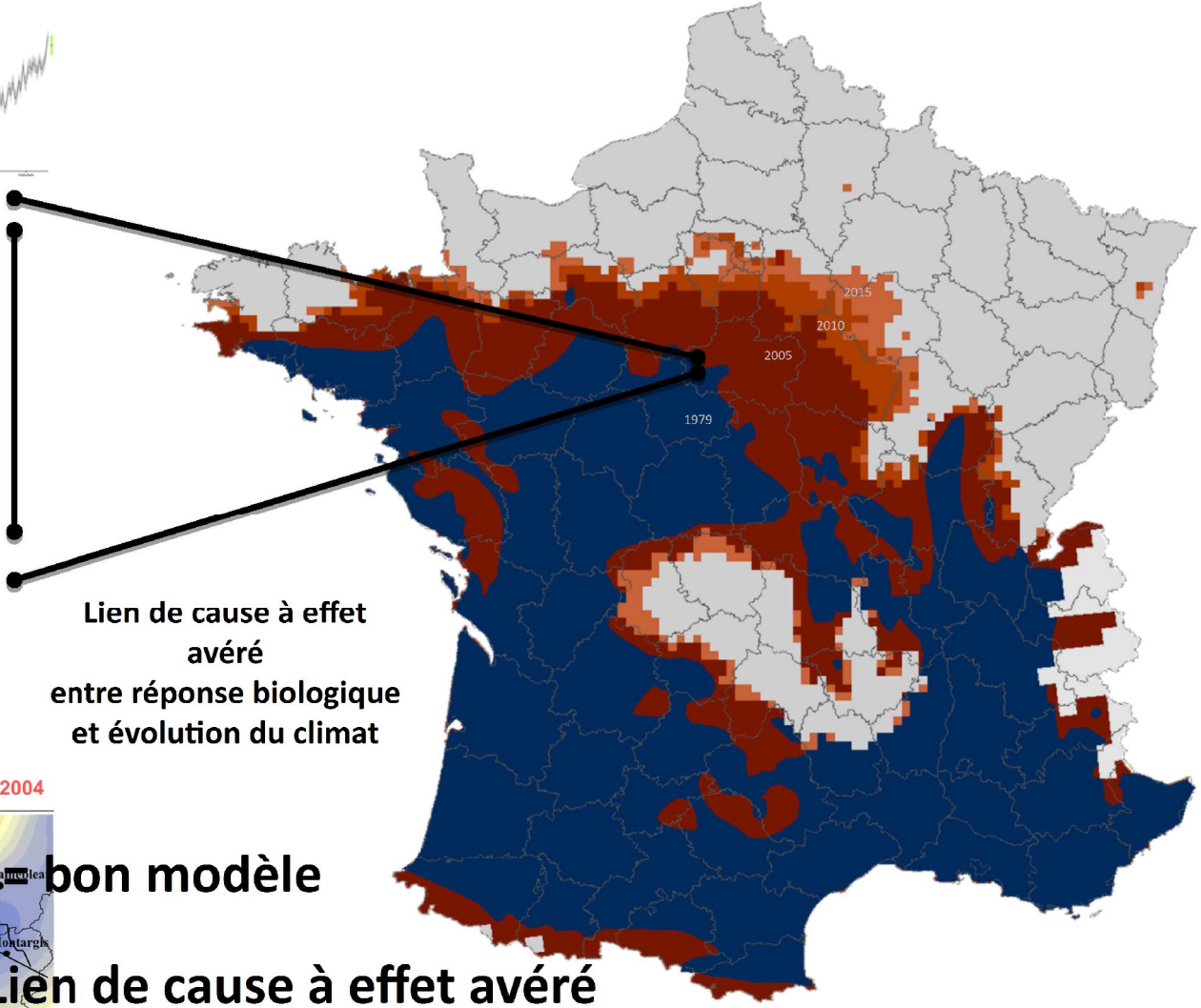

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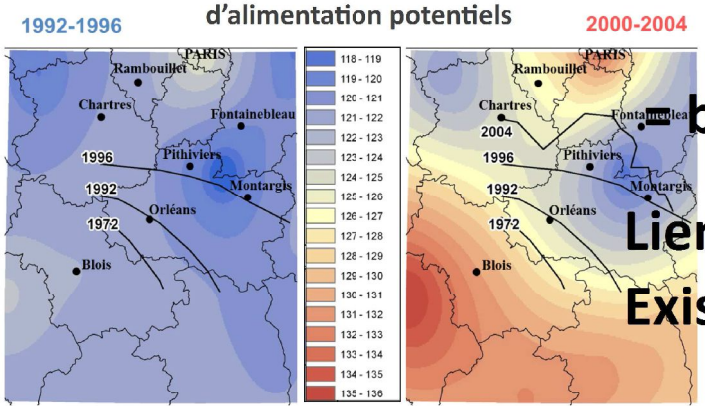
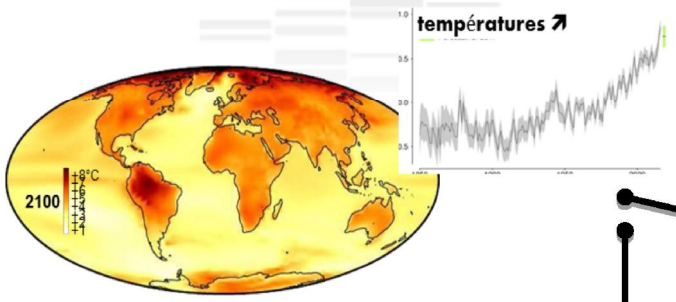


- bon modèle

Lien de cause à effet avéré

Existence de données historiques

Processionnaire du pin et réchauffement climatique



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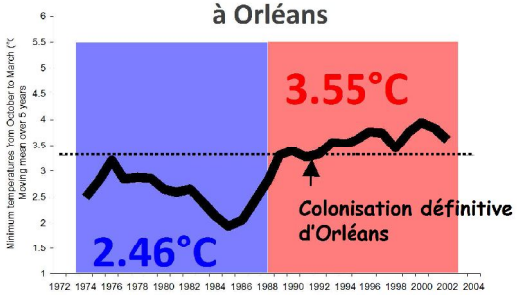
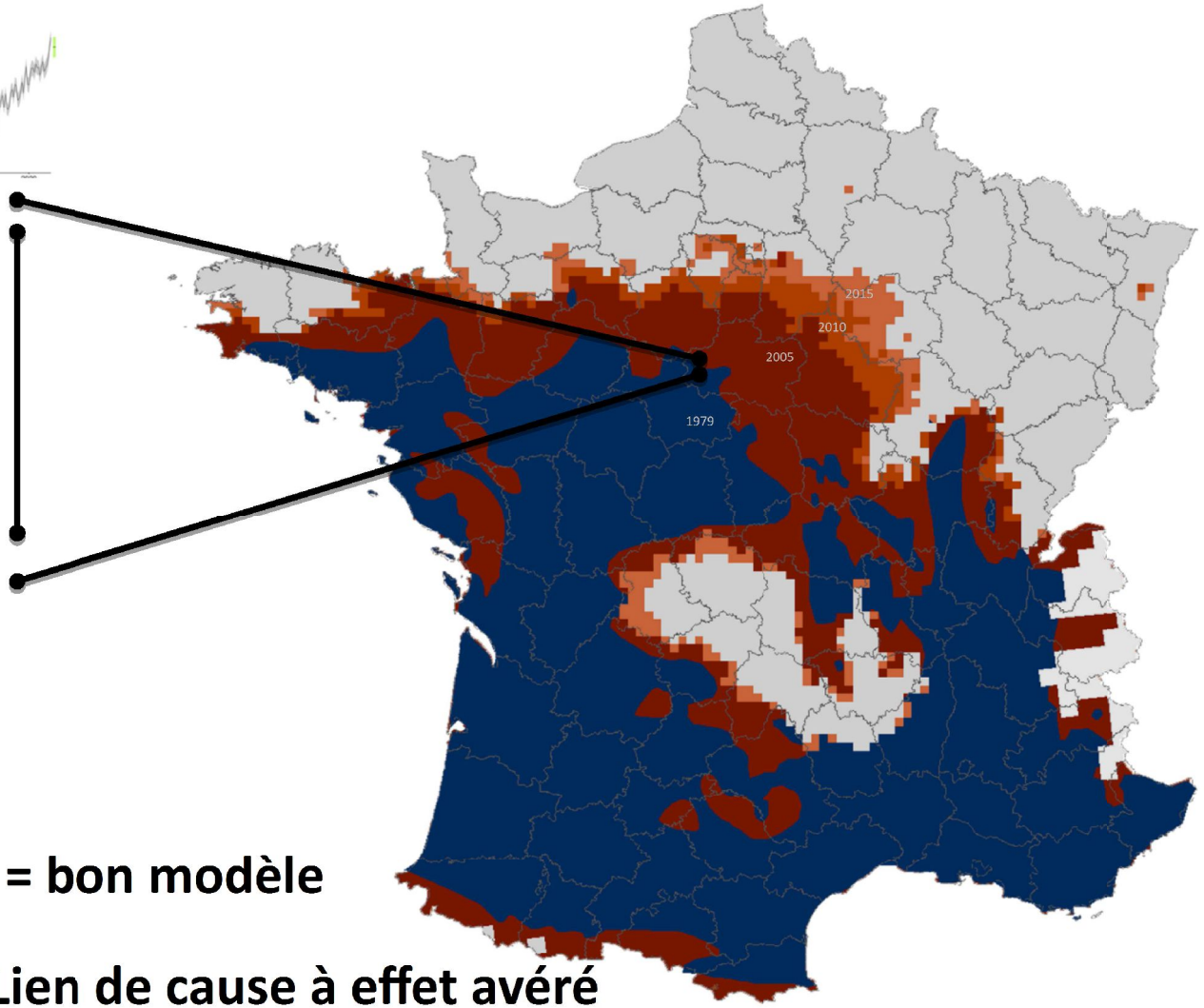




= bon modèle

Lien de cause à effet avéré

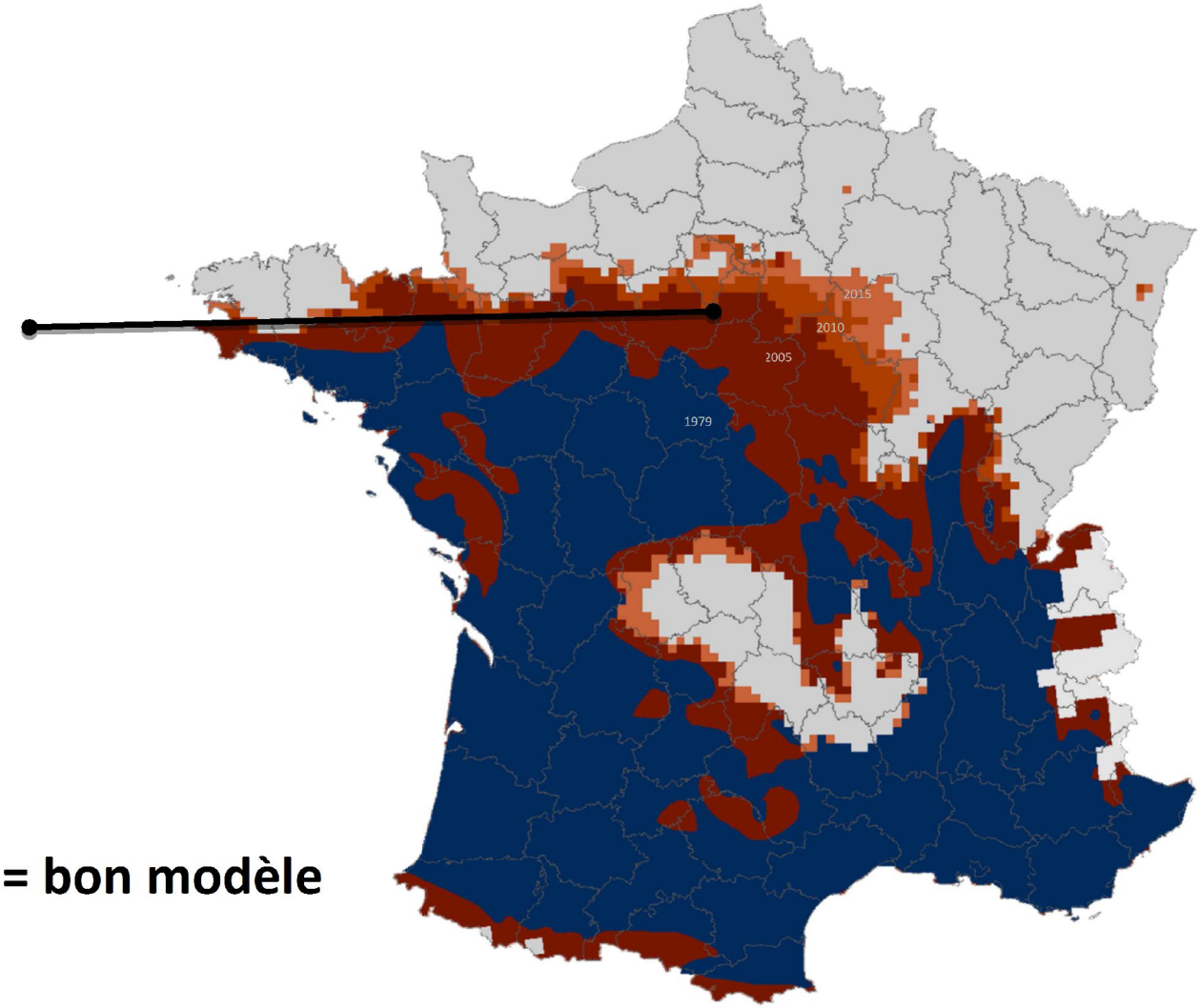
Existence de données historiques

Facilement cartographiable

Processionnaire du pin
cartographie de son aire de distribution

1400 km de front nord
= 60 000 km de voiture
+ 6 mois de travail

tous les 5 ans



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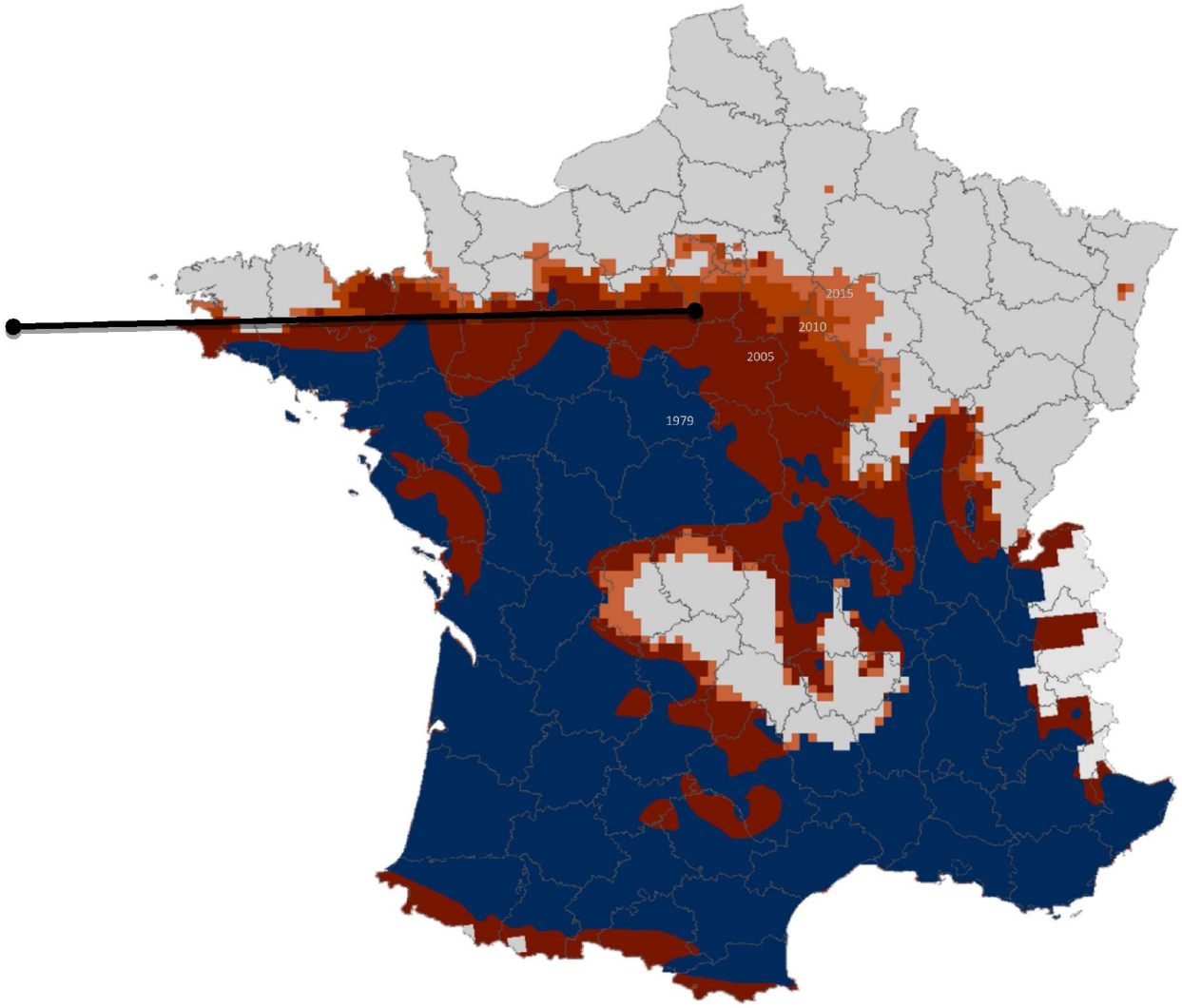
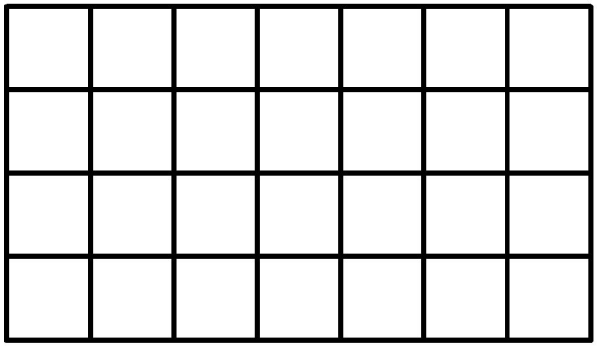


Grille de 8 x 8 km



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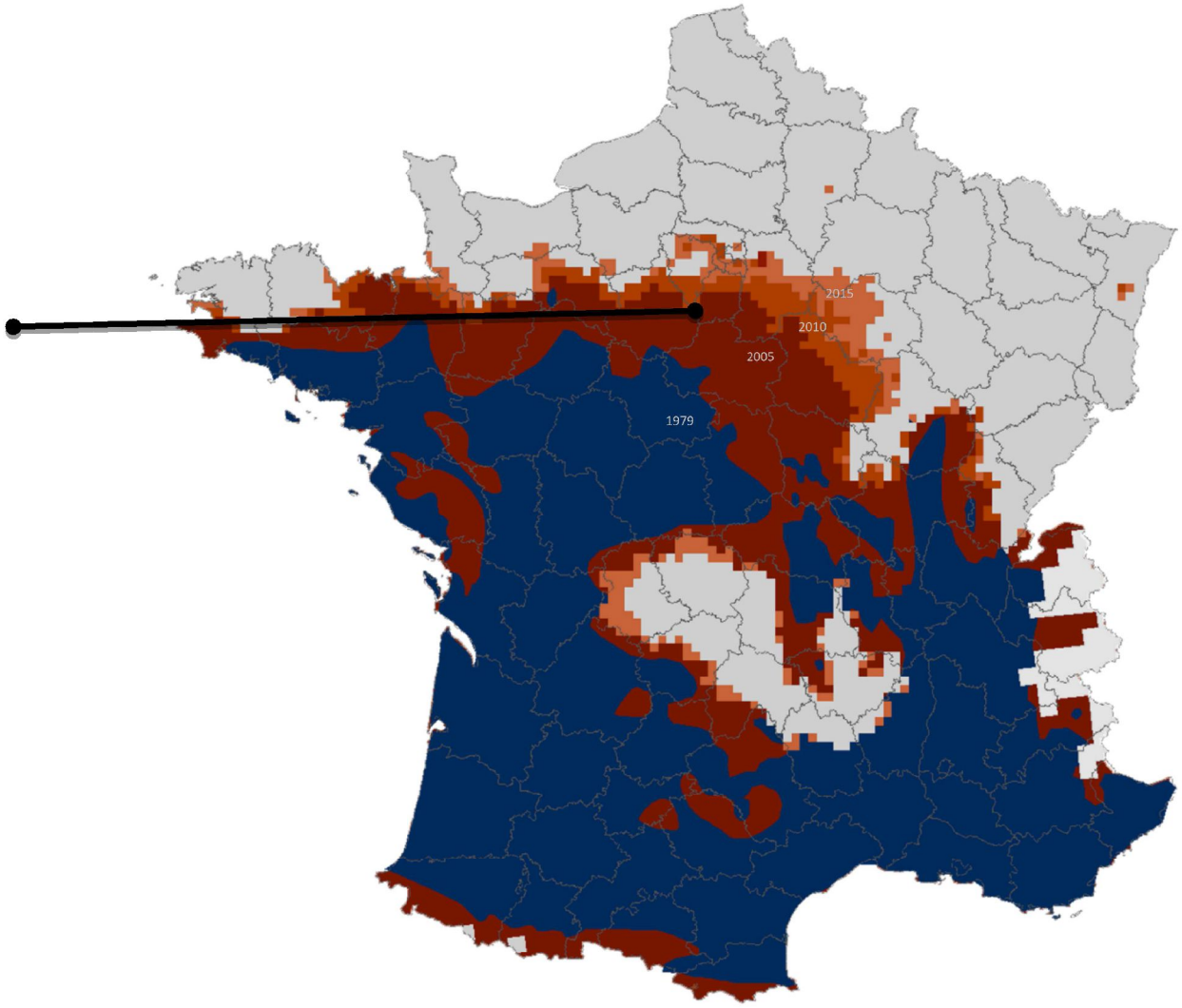

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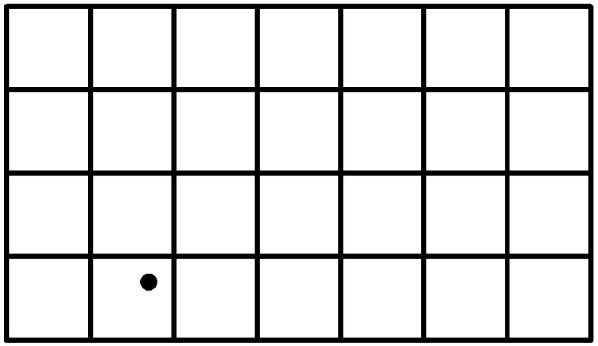

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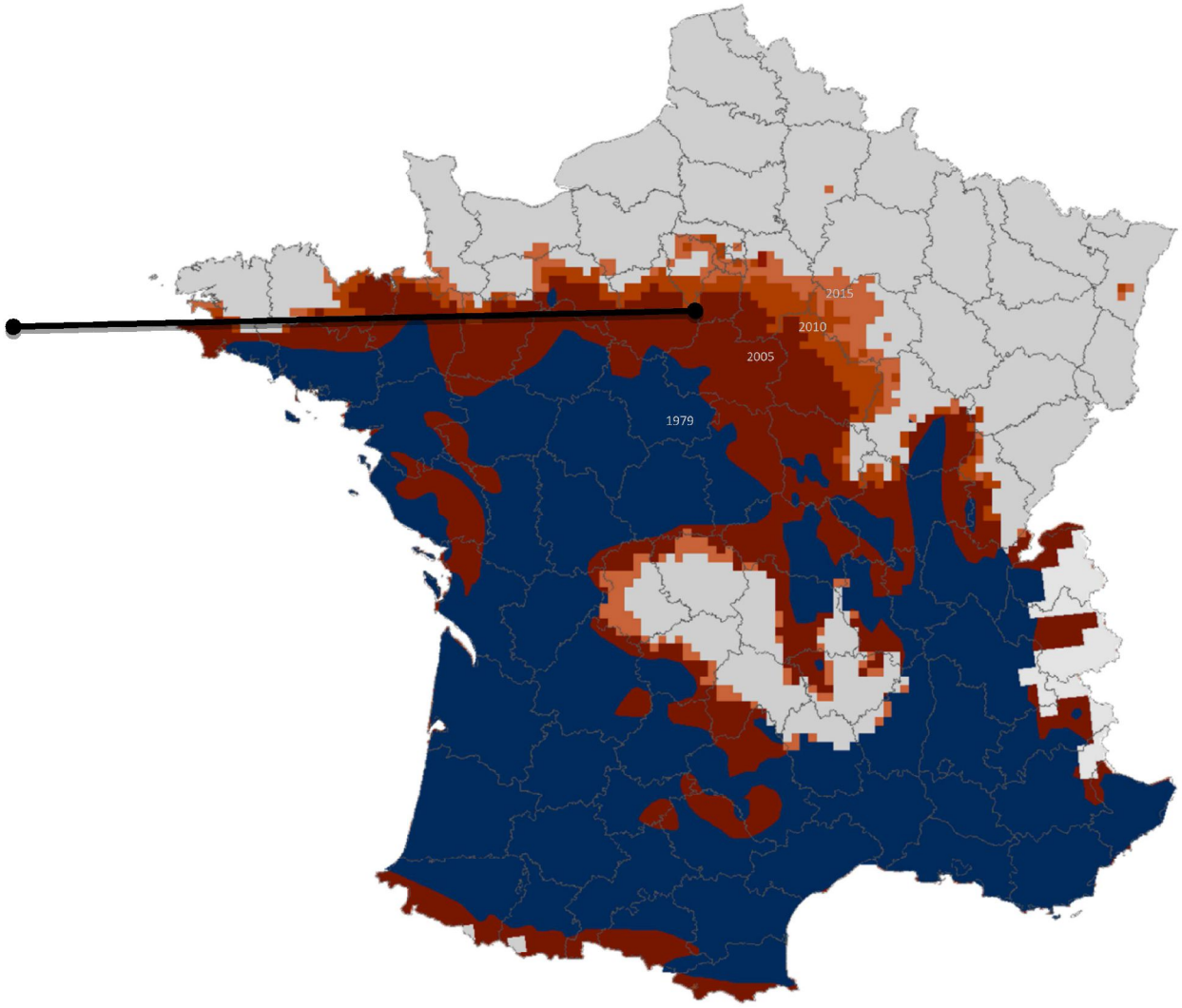

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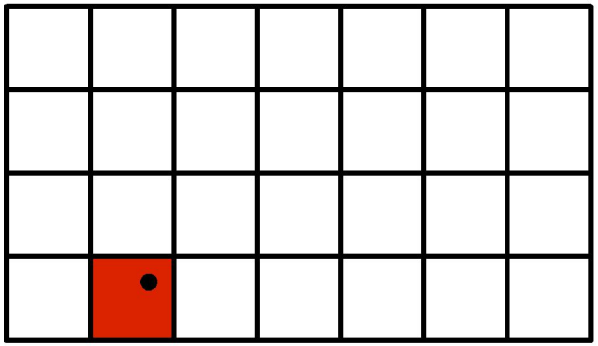

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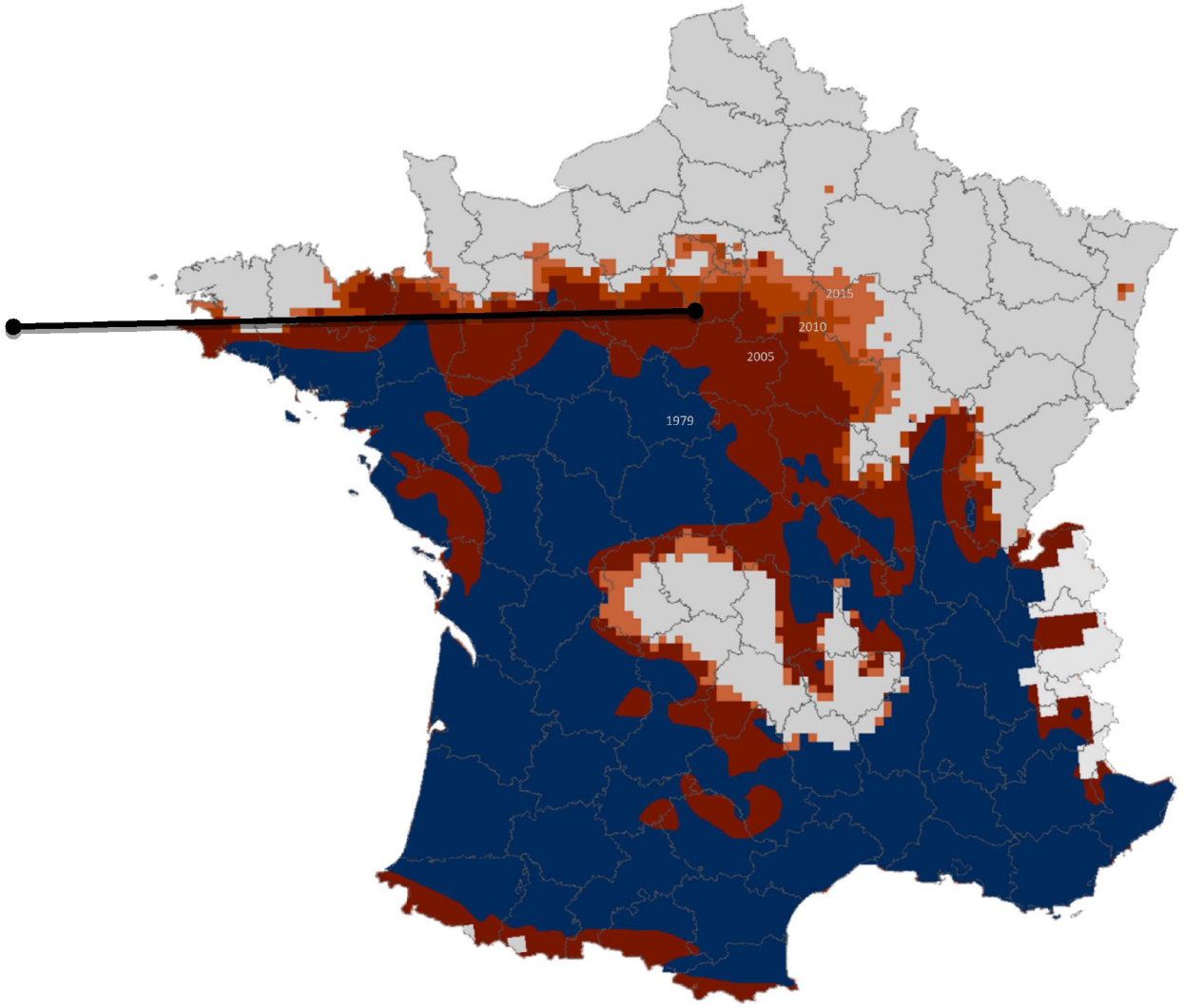

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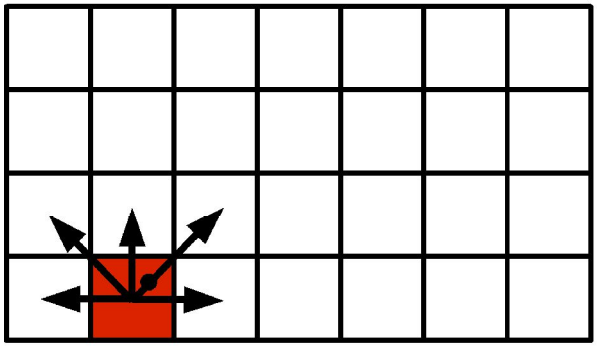

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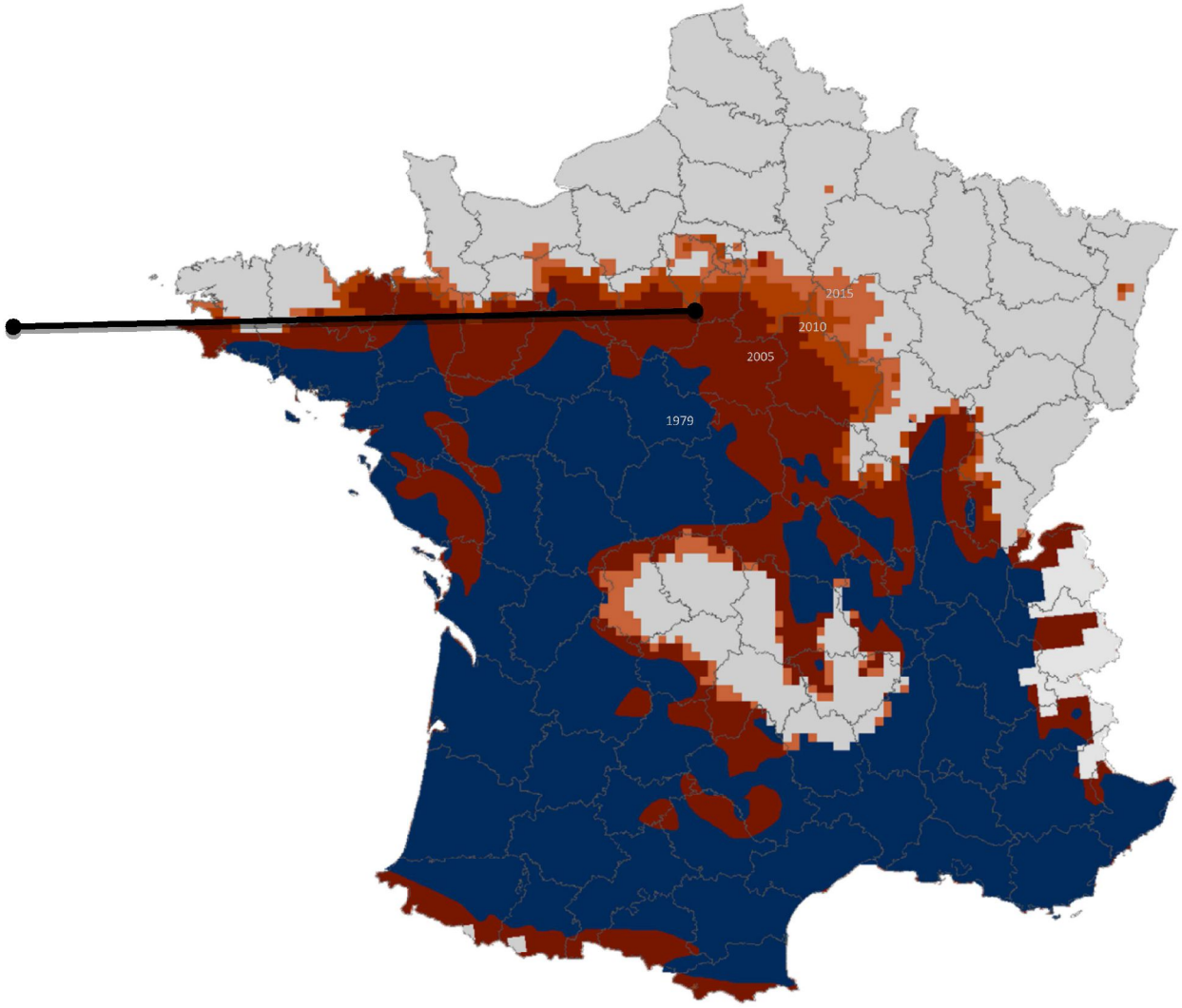

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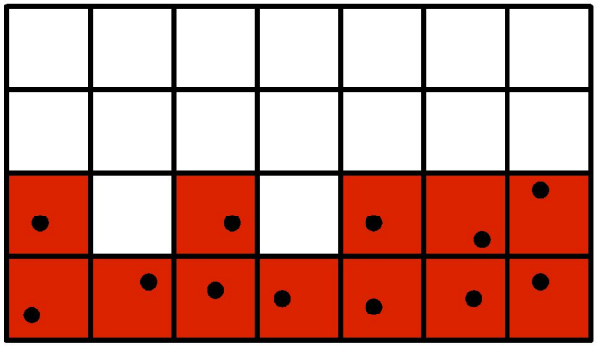

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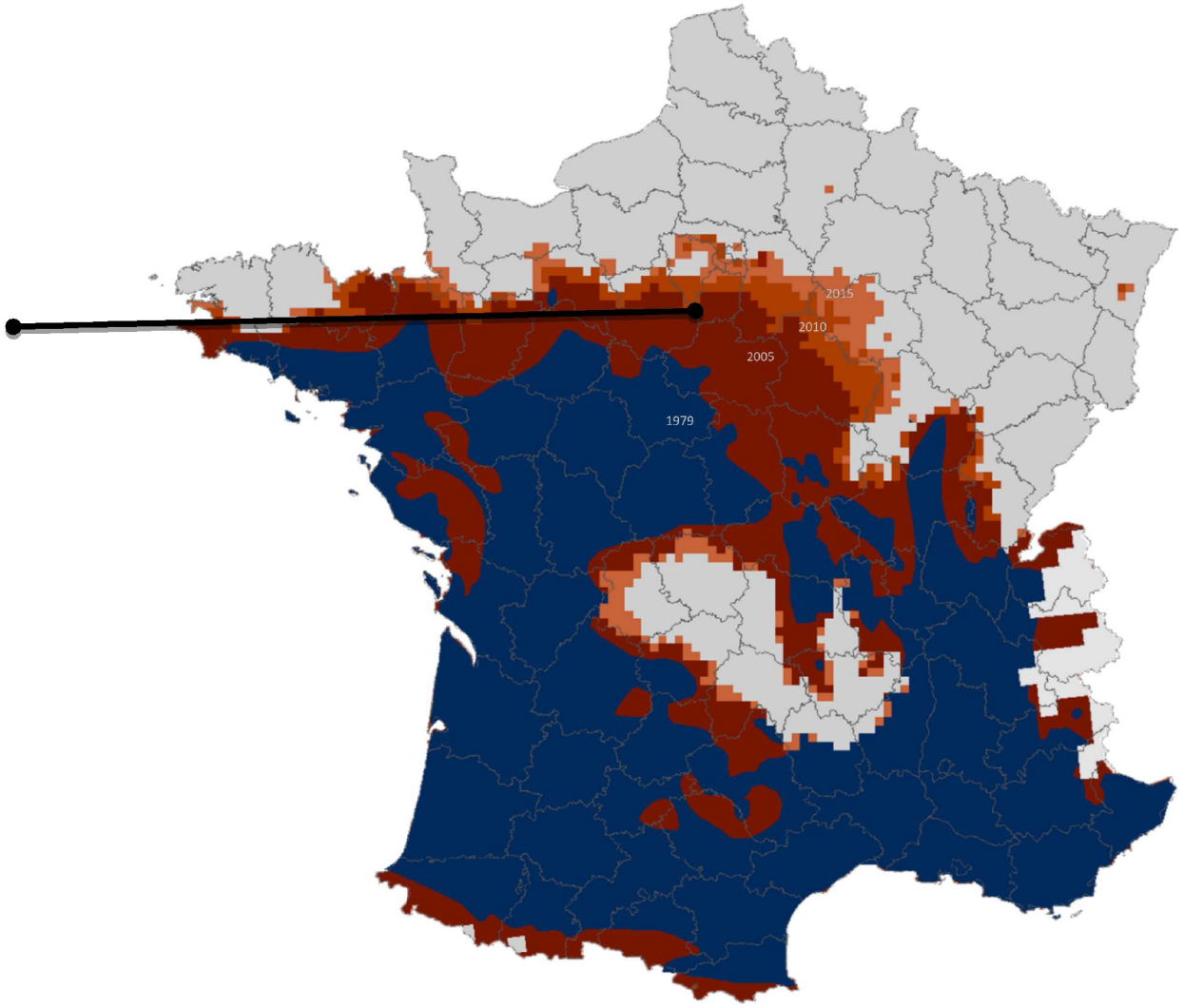

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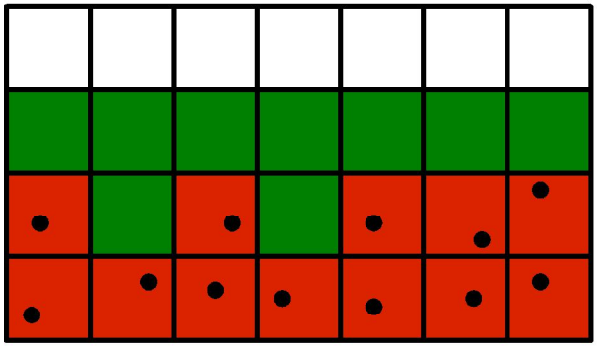

en moyenne 250 km de routes référencées dans la BD TOPO de l'IGN

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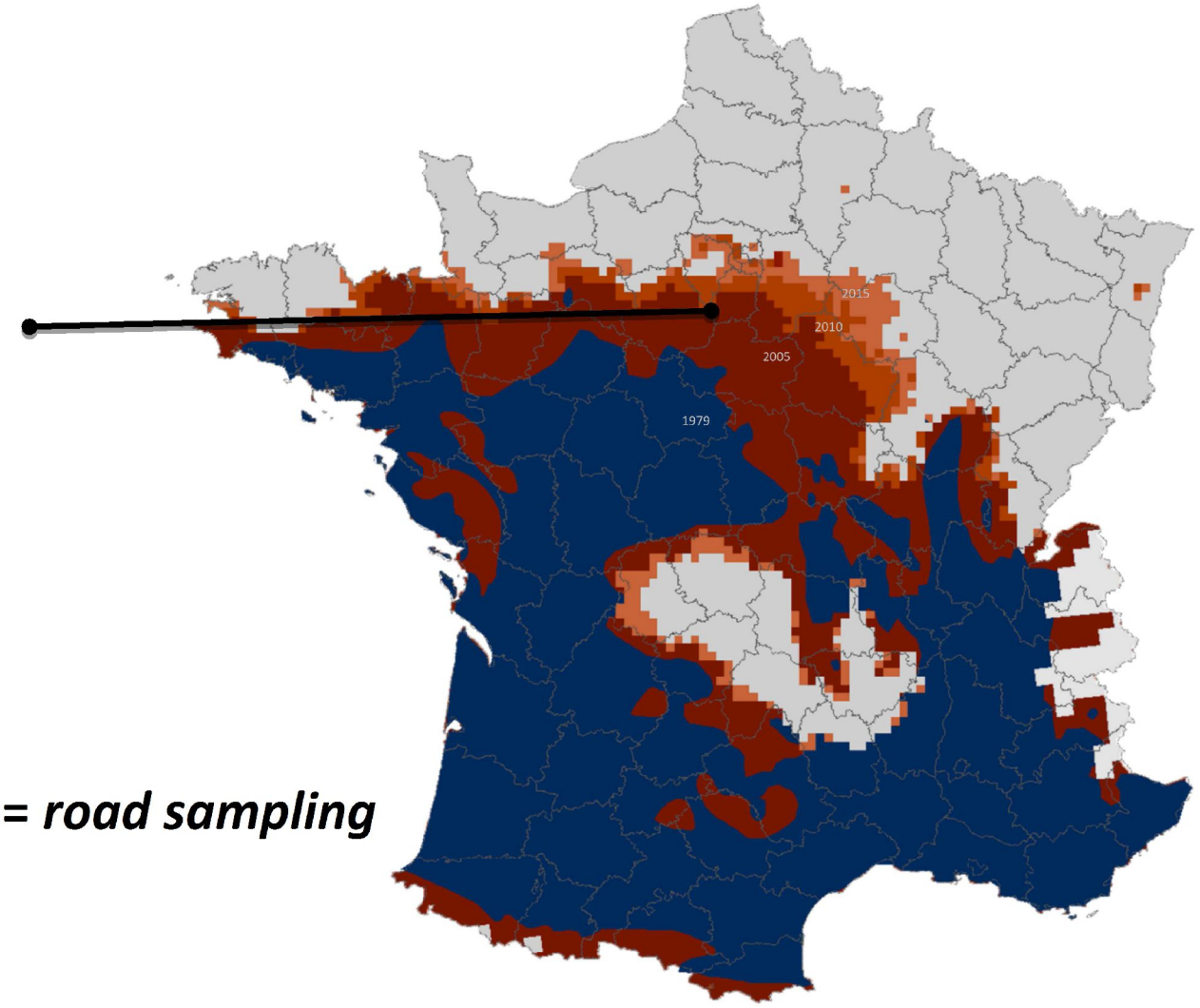

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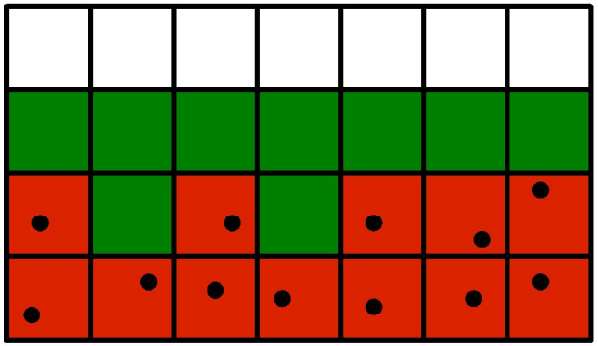

= road sampling

en moyenne 250 km de routes référencées dans la BD TOPO de l'IGN

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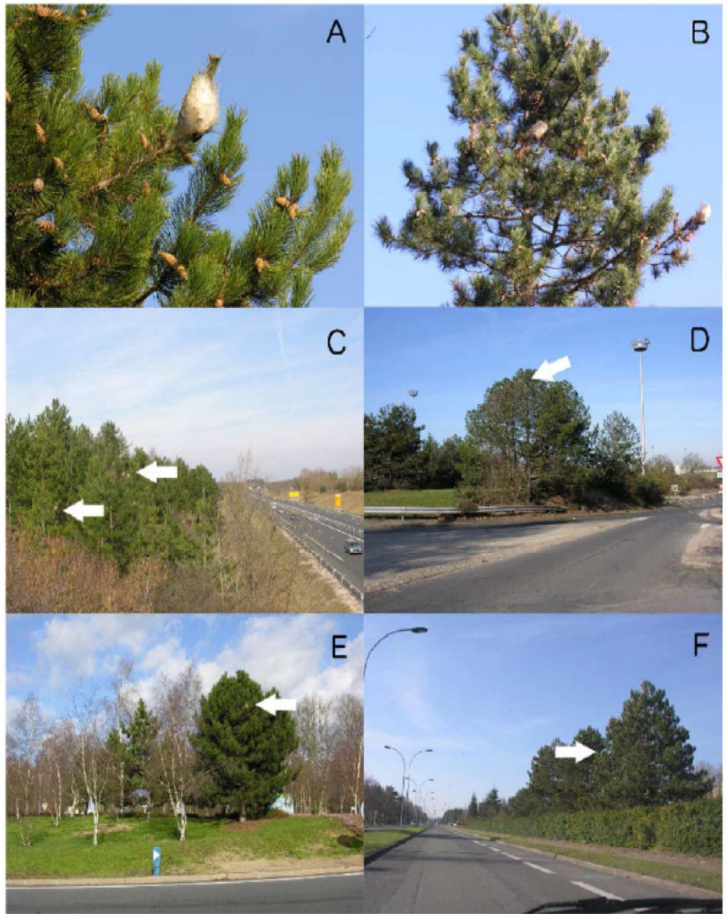
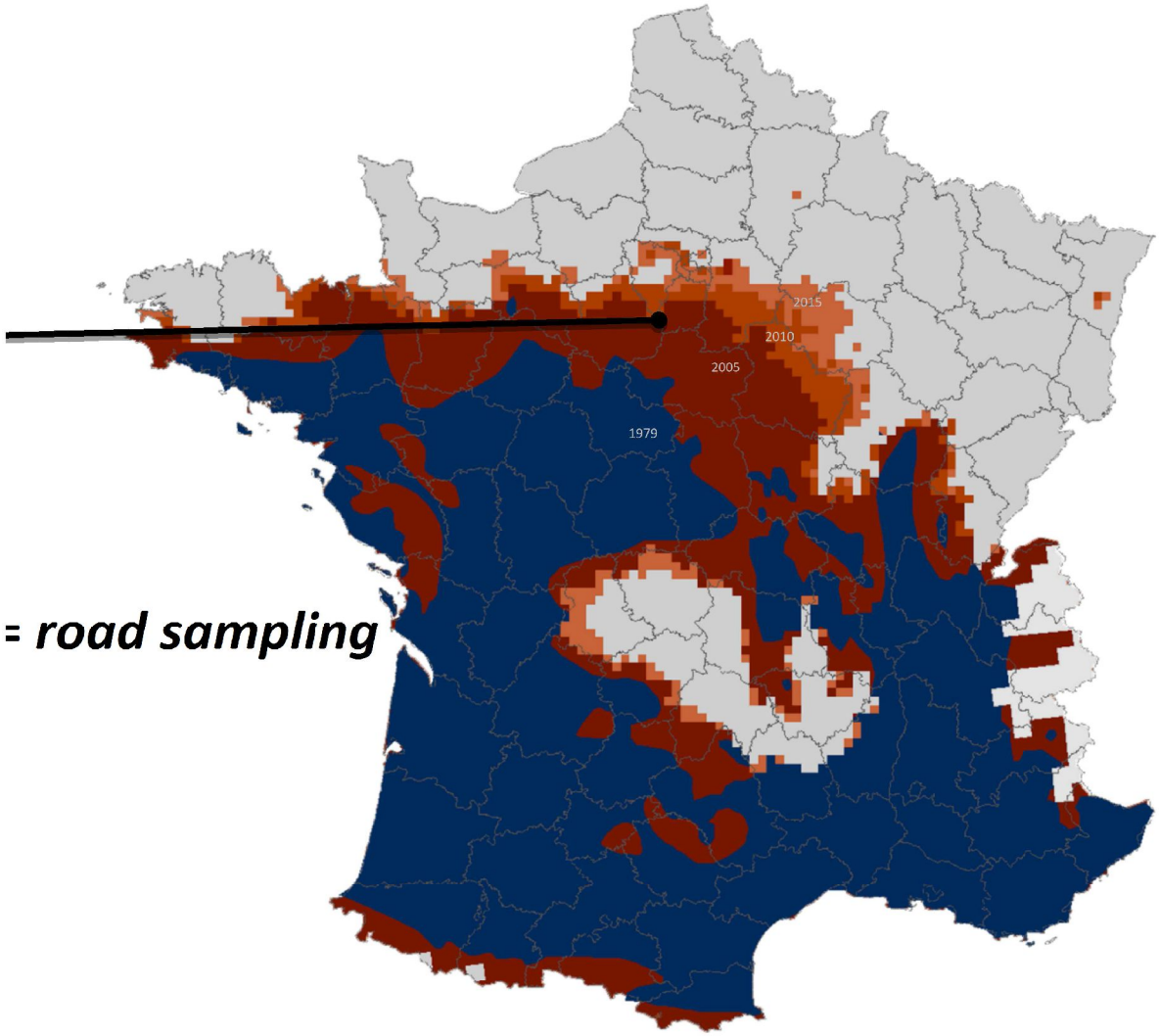


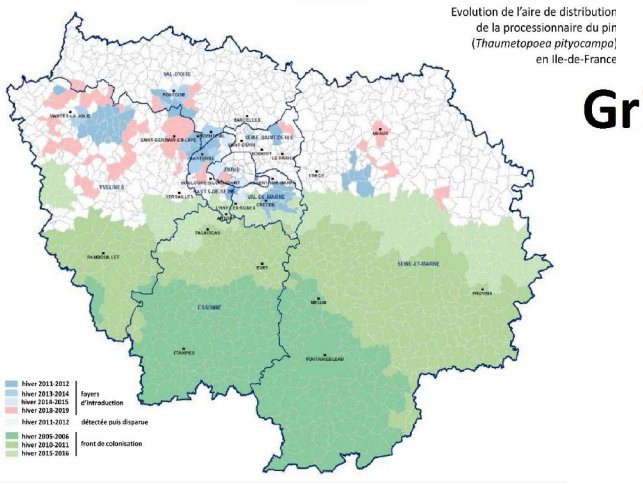
Figure 2. Pictures showing the pine processionary moth silk nest and different examples of infested trees located along streets in the region of Orléans, France. A. Winter silk nest. B. Host tree infested by several PPM colonies. C to E. Infested trees located along traffic lanes. F. Picture taken from within a car. All host trees are black pines (*Pinus nigra*) except in C. where black pines and scots pines (*P. sylvestris*) are present. All photos by J. Rousselet.
doi:10.1371/journal.pone.0074918.g002



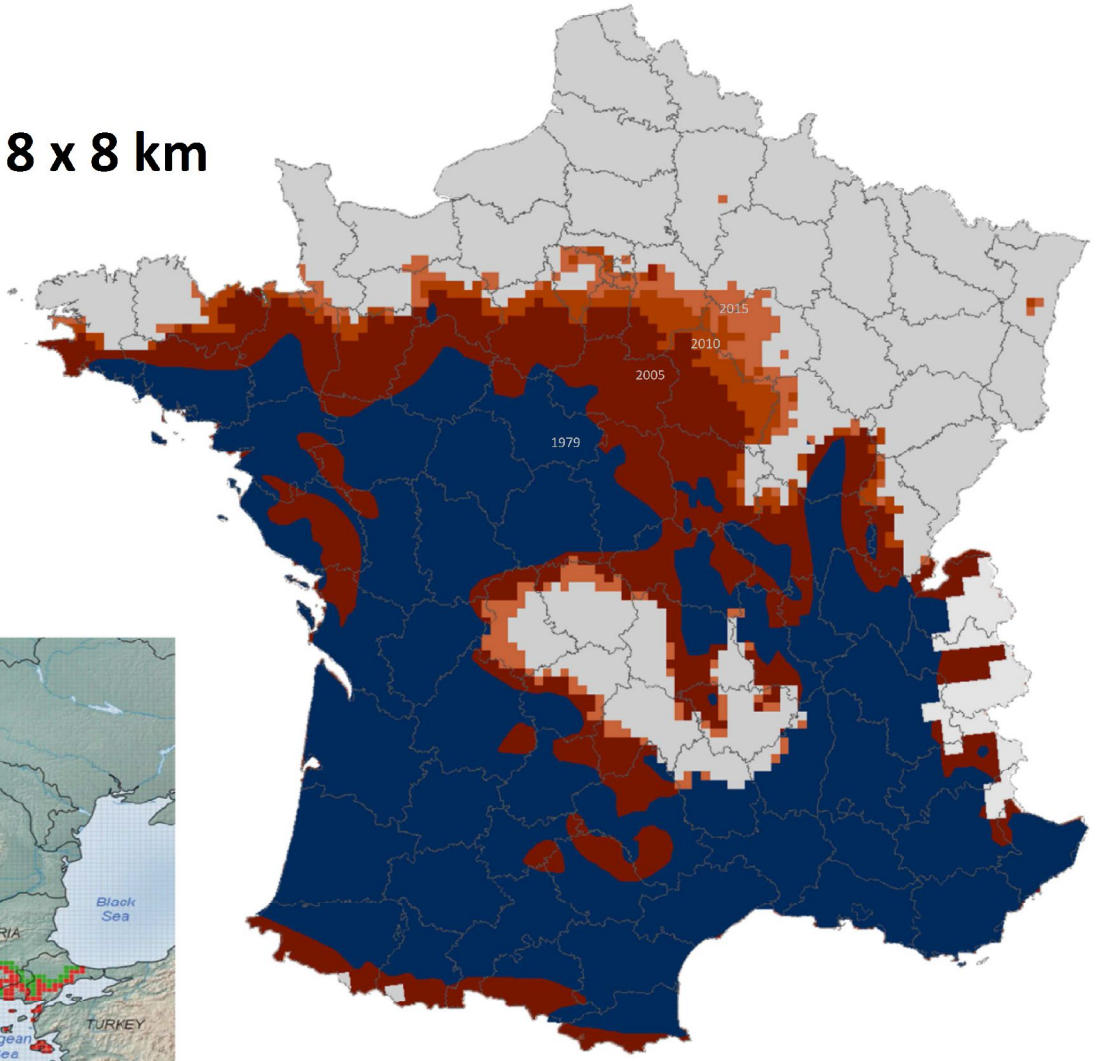
= *road sampling*

Processionnaire du pin
cartographie de son aire de distribution

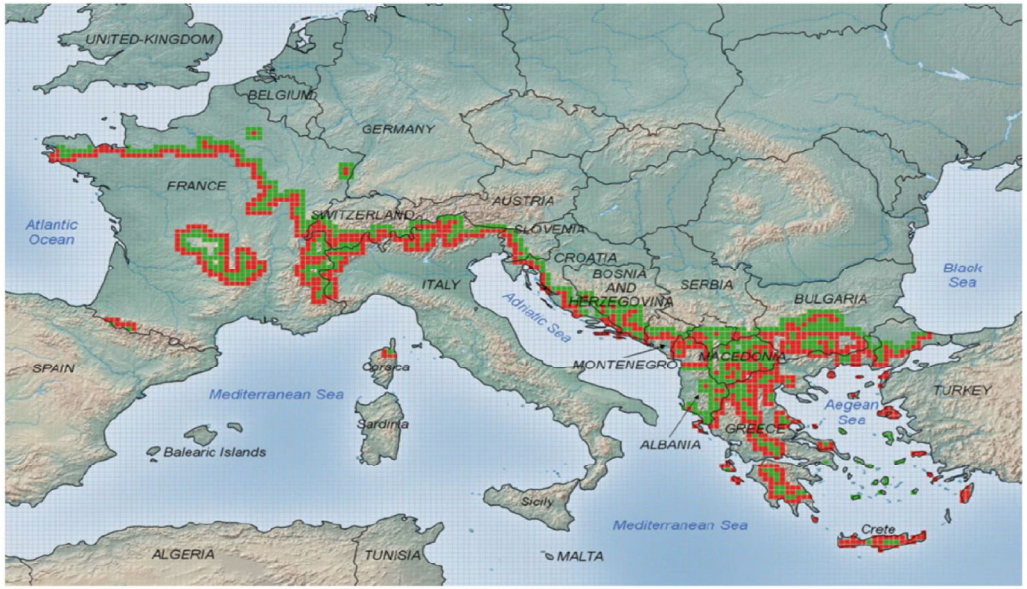
Grille de 1 x 1 km



Grille de 8 x 8 km



Grille de 16 x 16 km



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Assessing Species Distribution Using Google Street View: A Pilot Study with the Pine Processionary Moth

Jérôme Rousselet[1☯], Charles-Edouard Imbert[1☯], Anissa Dekri[1], Jacques Garcia[1], Francis Goussard[1], Bruno Vincent[1], Olivier Denux[1], Christelle Robinet[1], Franck Dorkeld[2], Alain Roques[1], Jean-Pierre Rossi[2]*

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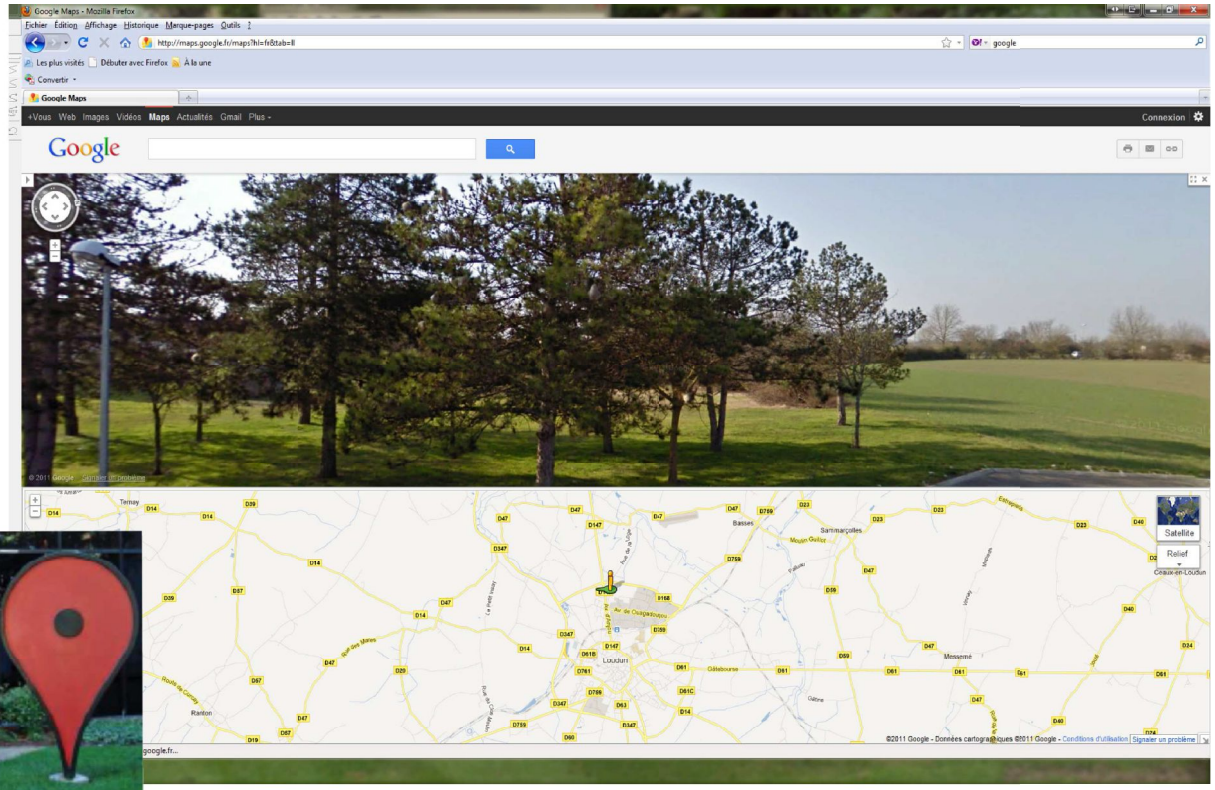

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During the last decade, geospatial data have become increasingly accessible with the advent of new mapping technologies such as Google Earth that offers free satellite imagery and aerial photos of most of earth's land surface. Google Earth has been used in several research areas that require mapping technology such as human or animal health [15,16], conservation biology [17,18] or biodiversity assessment [19]. A new level of spatial information has been recently reached with the development of Google street view (GSV) in 2007 [20]. This new technology provides panoramic imagery captured in hundreds of cities in different countries around the world. It corresponds to an unprecedented amount of information at street-level scale. Not only dedicated to cities and urban areas, GSV documents rural areas and unpopulated places.

GSV is based on the idea of operating numerous data-collection vehicles around the world. Each vehicle is equipped with camera and GPS, and records images while driving paved and unpaved roads. Resulting data are processed and served via the Internet [20]. Street imagery consists of detailed views allowing users to navigating and exploring streets and cities [21]. The aim of the present study was to explore how the GSV technology could be helpful to ecological research in documenting the geographical distribution of species. Recent studies have shown that the GSV imagery could be used to depict and audit neighborhood environments in the framework of social science [22] and preventive medicine [23] but to our knowledge, no ecological application has been published so far.

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How Google Street View Could Fight Invasive Species

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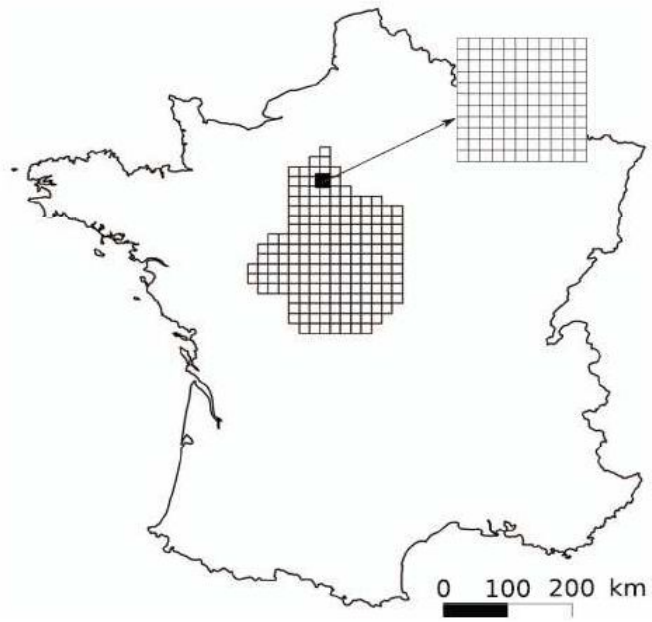


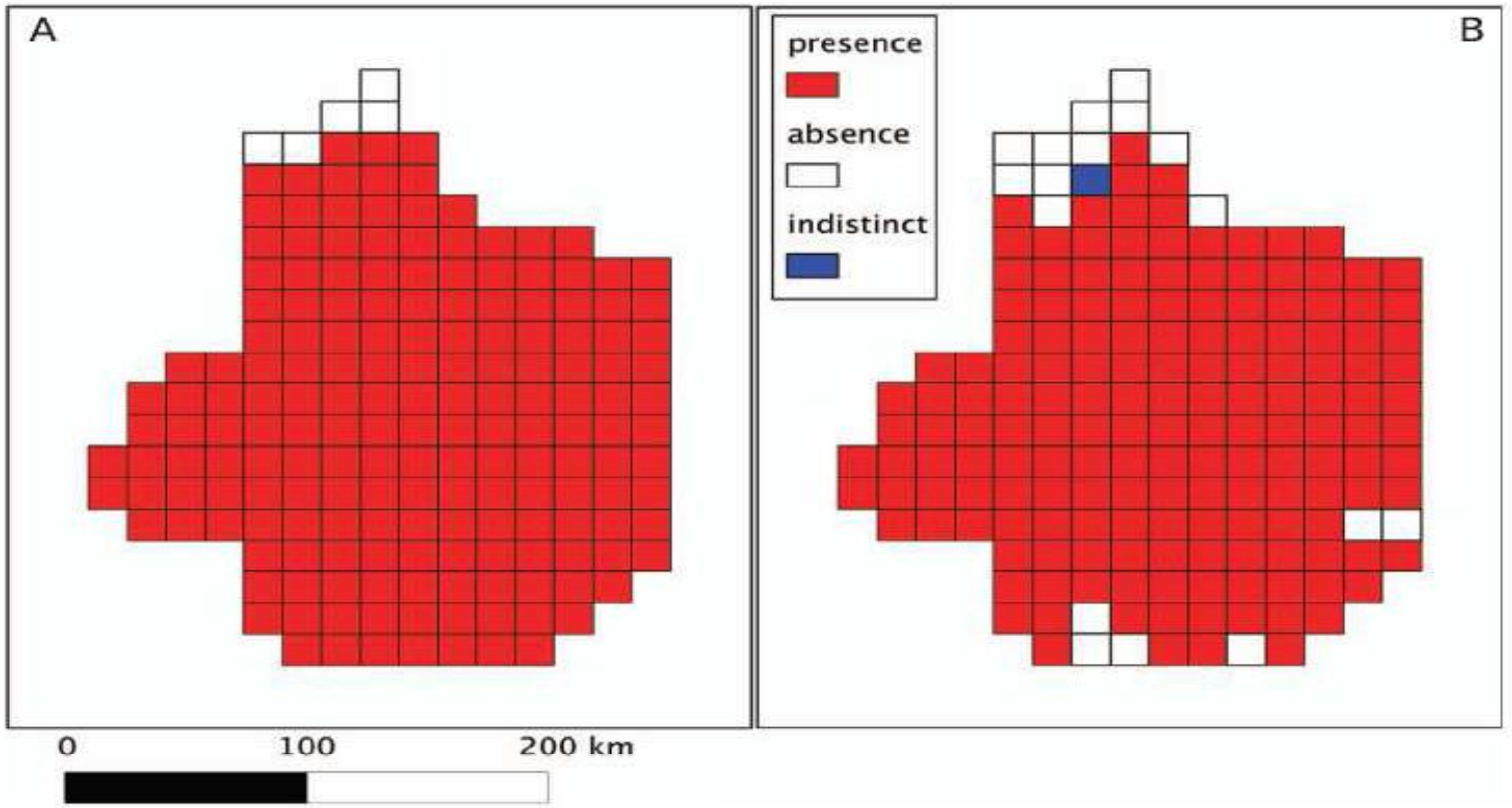
Figure 1. Pine processionary moth sampling grids. A large sampling grid covering the administrative region called "Région Centre" (46 848 km^2) in France was investigated. A second, smaller (121 km^2), sampling grid was nested within the former.
doi:10.1371/journal.pone.0074918.g001

⇨ **données GSV**

⇨ **données de terrain**

⇨ **2 étendues et 2 grains différents**

Figure 3. Large-scale study of the pine processionnary moth in France. A. Field data B. Google street view derived data. The sampling units are cells of 16 km × 16 km.
doi:10.1371/journal.pone.0074918.g003



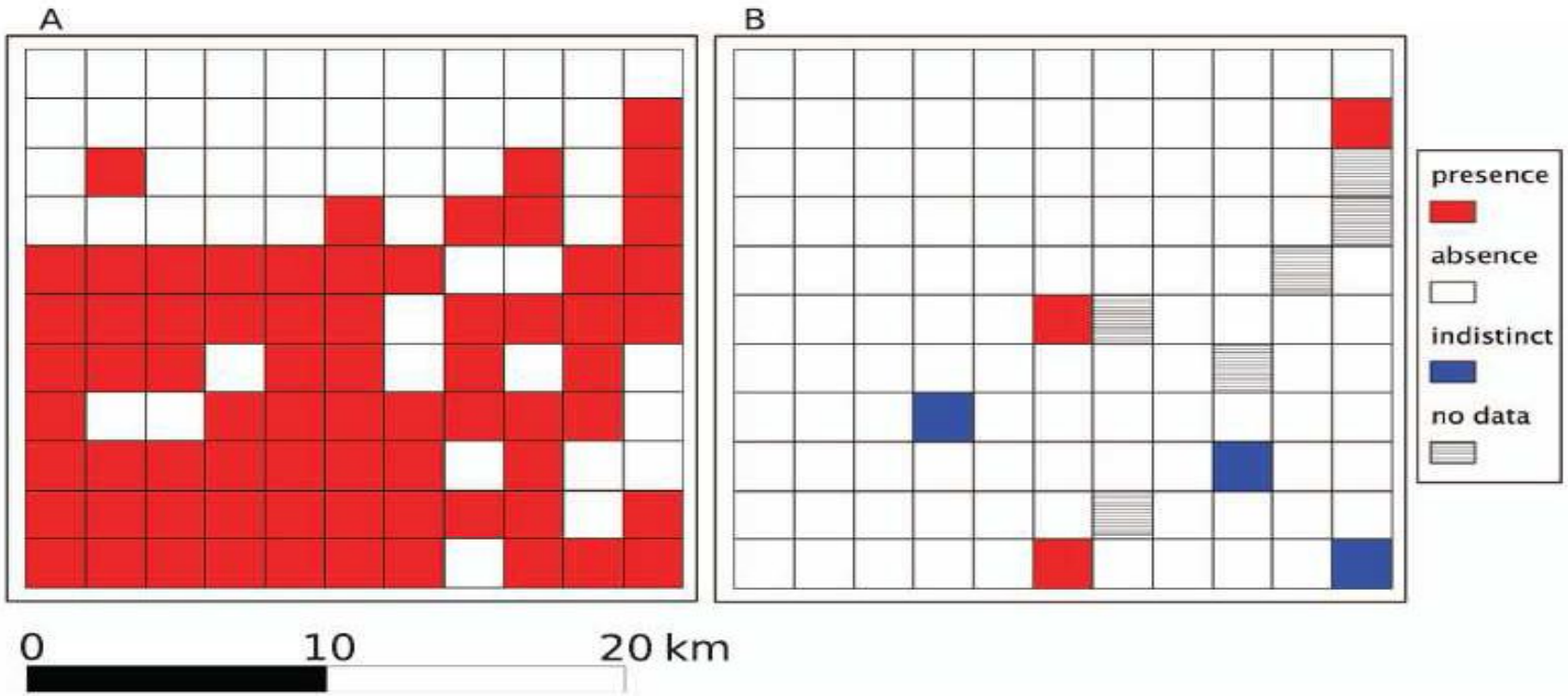
16 km x 16 km

Table 1. Confusion matrix for the pine processionnary moth field data (true class) and Google-derived data (hypothetized class) in the large-scale study grid (LG).

		field data	
		presence	**absence**
Google	presence	TP = 165	FP = 0
	absence	FN = 13	TN = 5

doi:10.1371/journal.pone.0074918.t001

Figure 4. Small-scale study of the pine processionary moth in France. A. Field data B. Google street view derived data. The sampling units are cells of 2 km×2 km.
doi:10.1371/journal.pone.0074918.g004



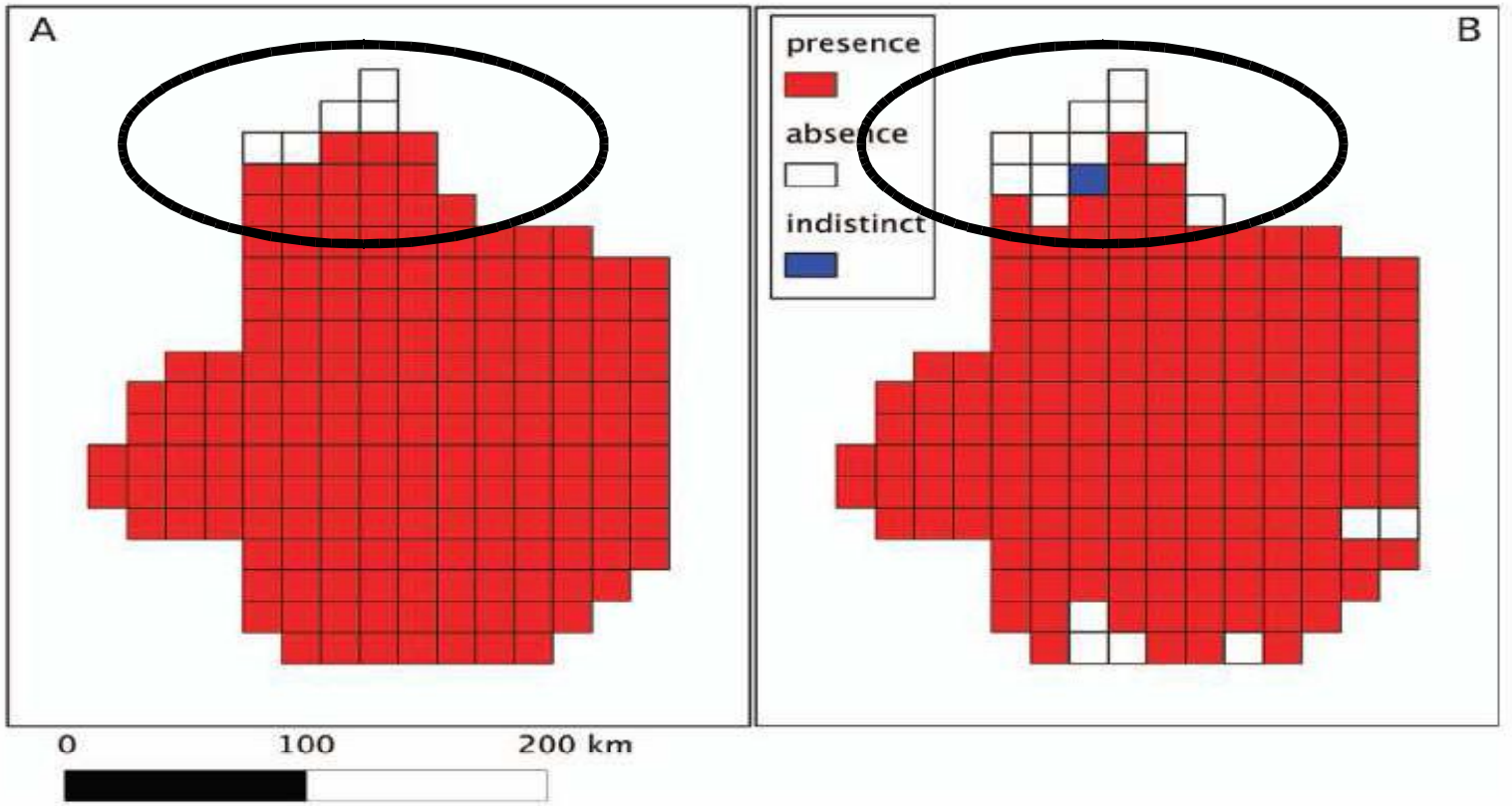
2 km x 2 km

Table 2. Confusion matrix for the pine processionnary moth field data (true class) and Google-derived data (hypothetized class) in the small-scale study grid (SG).

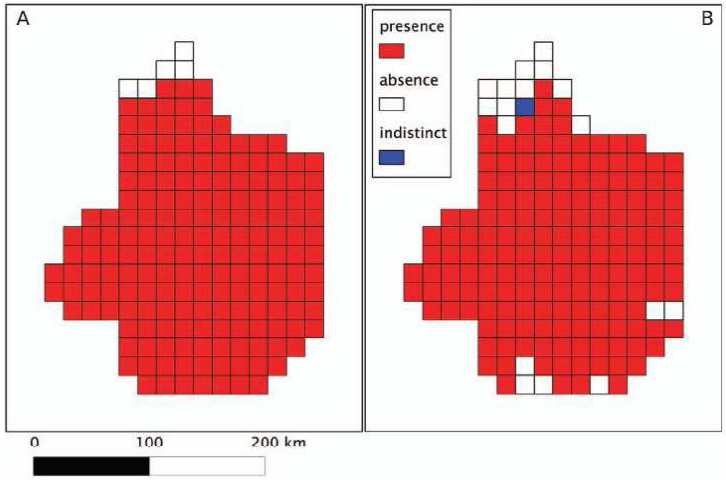
		field data	
		presence	**absence**
Google	presence	TP = 3	FP = 0
	absence	FN = 63	TN = 49

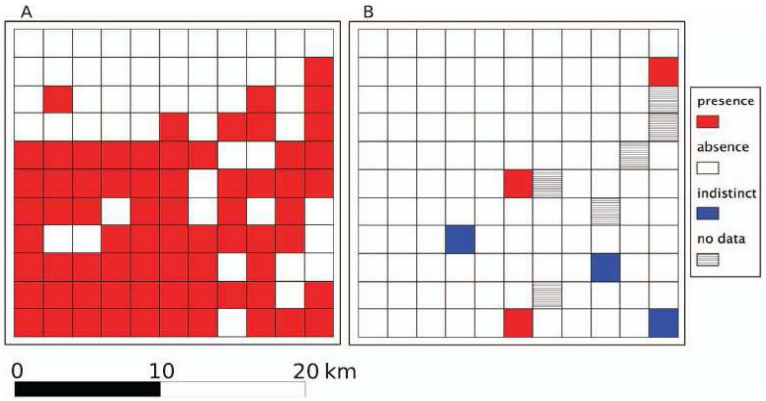
Of the 121 sampled cells, 6 were removed from the analysis because no GSV data were available for comparison with field data.
doi:10.1371/journal.pone.0074918.t002

Figure 3. Large-scale study of the pine processionnary moth in France. A. Field data B. Google street view derived data. The sampling units are cells of 16 km × 16 km.
doi:10.1371/journal.pone.0074918.g003



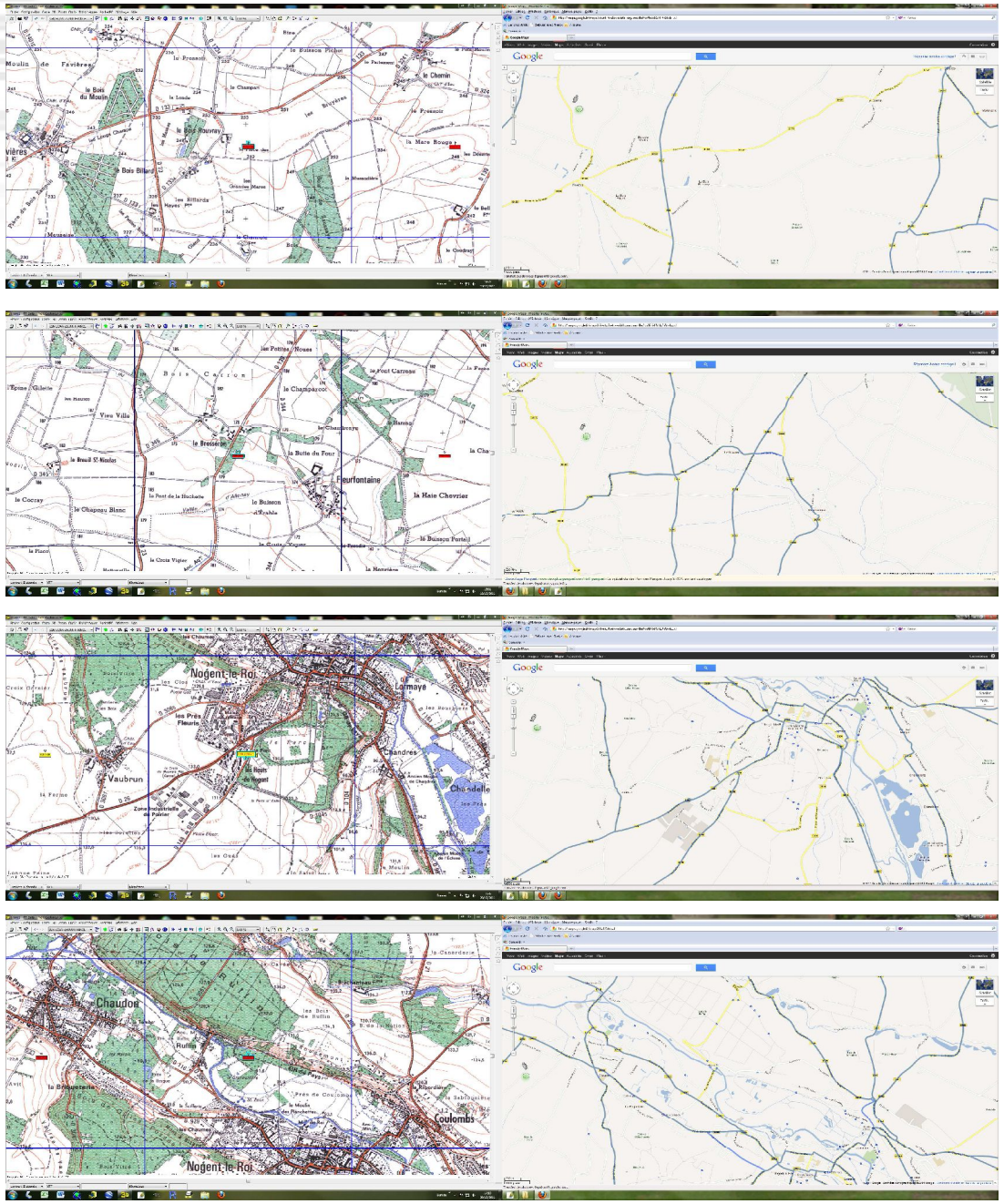
16 km x 16 km



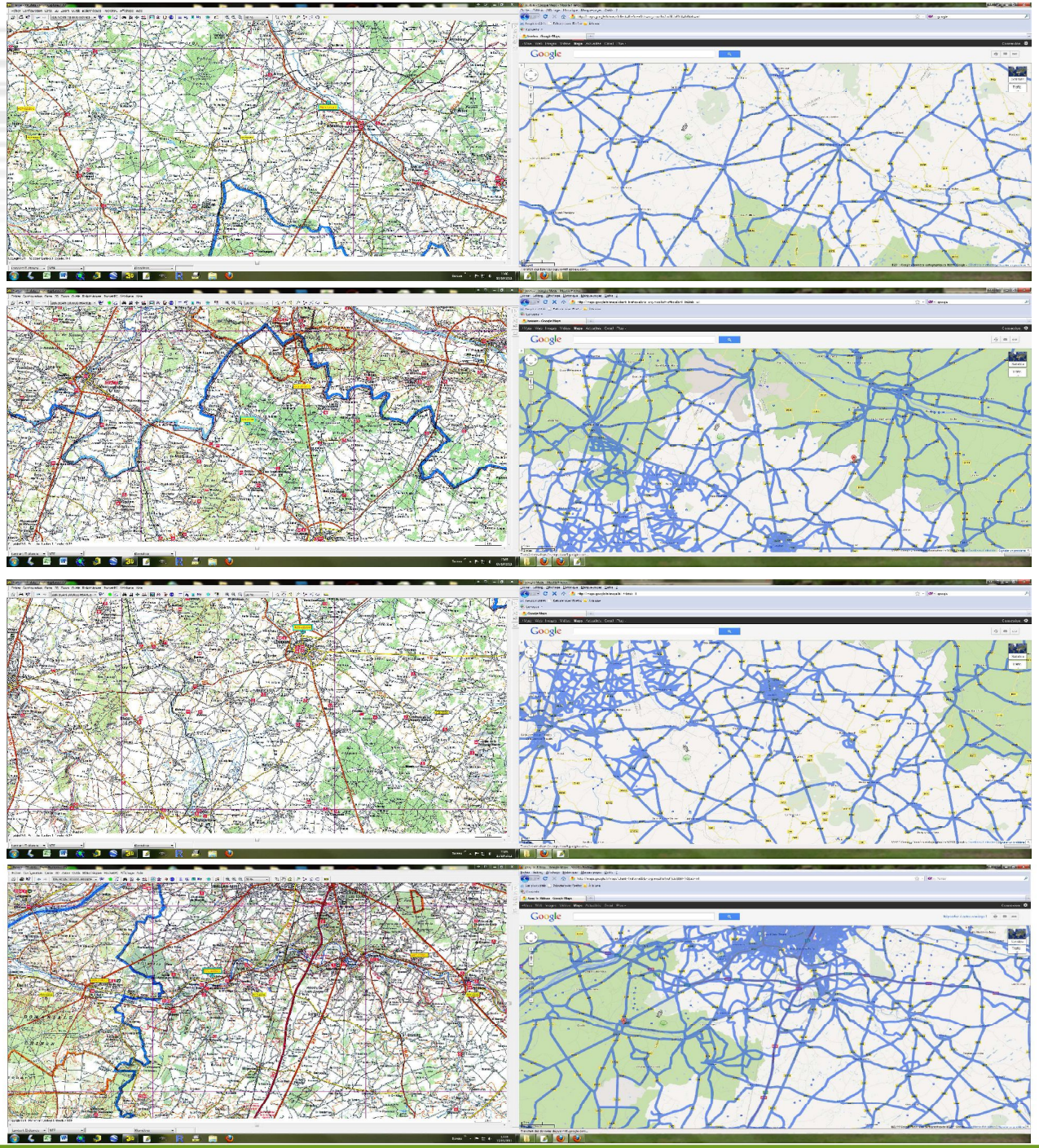


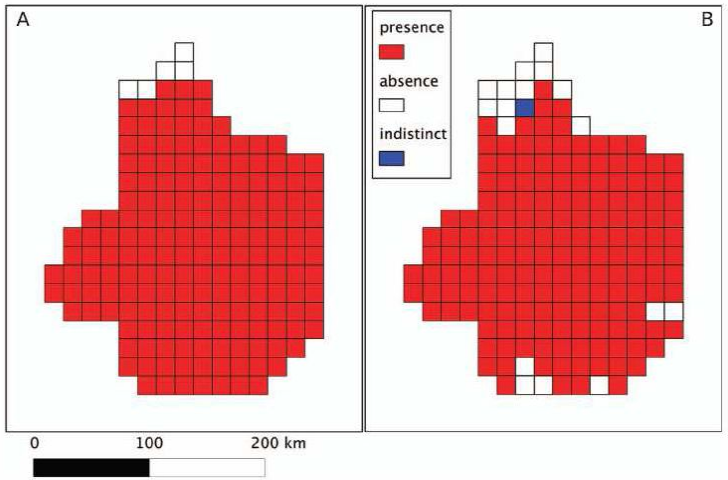
- ⇨ **densité de routes**
- ⇨ **densité de routes couvertes par GSV**
- ⇨ **date de prise de vue**

2 km x 2 km



16 km x 16 km

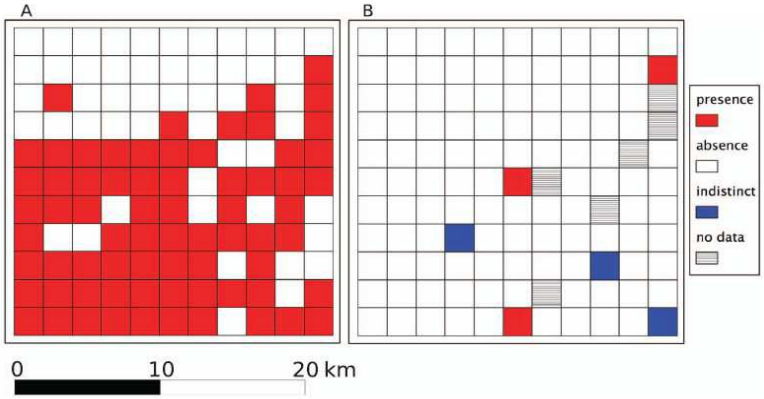




16 km x 16 km

erreur structurée spatialement ???

8 km x 8 km



2 km x 2 km

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PLOS ONE

Assessing Species Distribution Using Google Street View: A Pilot Study with the Pine Processionary Moth

Jérôme Rousselet[1☯], Charles-Edouard Imbert[1☯], Anissa Dekri[1], Jacques Garcia[1], Francis Goussard[1], Bruno Vincent[1], Olivier Denux[1], Christelle Robinet[1], Franck Dorkeld[2], Alain Roques[1], Jean-Pierre Rossi[2*]

1 Unité de Recherche 633 Zoologie Forestière, Institut National Recherche Agronomique, Centre d'Orléans, France, **2** Unité Mixte de Recherche 1062 Centre de Biologie pour la Gestion des Populations, Institut National Recherche Agronomique, Centre de Montpellier, France

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Assessing Species Habitat Using Google Street View: A Case Study of Cliff-Nesting Vultures

Pedro P. Olea*, Patricia Mateo-Tomás

Instituto de Investigación en Recursos Cinegéticos, Consejo Superior de Investigaciones Científicas-University of Castilla-La Mancha-Junta de Comunidades de Castilla-La Mancha, Ciudad Real, Spain

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Assessing Species Distribution Using Google Street View: A Pilot Study with the Pine Processionary Moth

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Received April 3, 2013; **Accepted** August 8, 2013; **Published** October 9, 2013

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Mapping oak shoot browning in SW Spain using online imagery as virtual prospecting tool

Luis M. Torres-Vila [1] · A. Cristina Echave-Sanabria [2] · F. Javier Mendiola-Díaz [1] · Francisco J. Moral-García [3]

Received: 24 October 2018 / Accepted: 7 March 2019

Assessing residential front yards using Google Street View and geospatial video: A virtual survey approach for urban pollinator conservation

Andrea Burr[a,*], Nicole Schaeg[a], Damon M. Hall[b]

[a] *Center for Sustainability, Saint Louis University, Saint Louis, MO, USA*
[b] *University of Missouri, School of Natural Resources, 103 Anheuser-Busch Natural Resources Building, and Department of Bioengineering, 254 Agricultural Engineering, Columbia, MO, 65211, USA*

+ 1 araignée
+ 1 plante

Google Street View shows promise for virtual street tree surveys

Adam Berland*, Daniel A. Lange

Department of Geography, Ball State University, Muncie, IN, USA

Green streets – Quantifying and mapping urban trees with street-level imagery and computer vision

Ian Seiferling[a,b,*], Nikhil Naik[c], Carlo Ratti[a], Raphäel Proulx[b]

[a] *Senseable City Laboratory, Department of Urban Studies and Planning, Massachusetts Institute of Technology, Room 10-485, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States*
[b] *Canada Research Chair in Ecological Integrity, Centre de Recherche sur les Interactions Bassins Versants-Ecosystemes Aquatiques, Universite du Quebec a Trois-Rivieres, 3351 Boulevard des Forges, Trois-Rivieres, Quebec, G9A 5H7, Canada*
[c] *MIT Media Lab, 75 Amherst St, Cambridge, MA 02139, United States*

Assessing street-level urban greenery using Google Street View and a modified green view index

Xiaojiang Li[a,*], Chuanrong Zhang[a], Weidong Li[a], Robert Ricard[b], Qingyan Meng[c], Weixing Zhang[a]

[a] *Department of Geography, University of Connecticut, Storrs, CT 06269, USA*
[b] *Department of Extension, University of Connecticut, West Hartford, CT 06117-2600, USA*
[c] *Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100101, China*

Understanding urban landuse from the above and ground perspectives: A deep learning, multimodal solution

Shivangi Srivastava[a,*], John E. Vargas-Muñoz[b], Devis Tuia[a]

[a] *Laboratory of Geo-information Science and Remote Sensing, Wageningen University & Research, the Netherlands*
[b] *Laboratory of Image Data Science, Institute of Computing, University of Campinas, Campinas, Brazil*

Using deep learning to examine street view green and blue spaces and their associations with geriatric depression in Beijing, China

Marco Helbich[a,1], Yao Yao[b,1], Ye Liu[c,d], Jinbao Zhang[c,d], Penghua Liu[c,d], Ruoyu Wang[b,c,d,*]

[a] Department of Human Geography and Spatial Planning, Utrecht University, Utrecht, The Netherlands
[b] School of Information Engineering, China University of Geosciences, Wuhan, China
[c] School of Geography and Planning, Sun Yat-Sen University, Guangzhou, China
[d] Guangdong Key Laboratory for Urbanization and Geo-Simulation, Sun Yat-Sen University, Guangzhou, China

Systematic review of the use of Google Street View in health research: Major themes, strengths, weaknesses and possibilities for future research☆

Amanda Rzotkiewicz[a,*], Amber L. Pearson[a,b,c], Benjamin V. Dougherty[a], Ashton Shortridge[a], Nick Wilson[c]

[a] Department of Geography, Environment, and Spatial Sciences, Michigan State University, East Lansing, MI, USA
[b] Environmental Science and Policy Program, Michigan State University, East Lansing, MI, USA
[c] Department of Public Health, University of Otago, Wellington, New Zealand

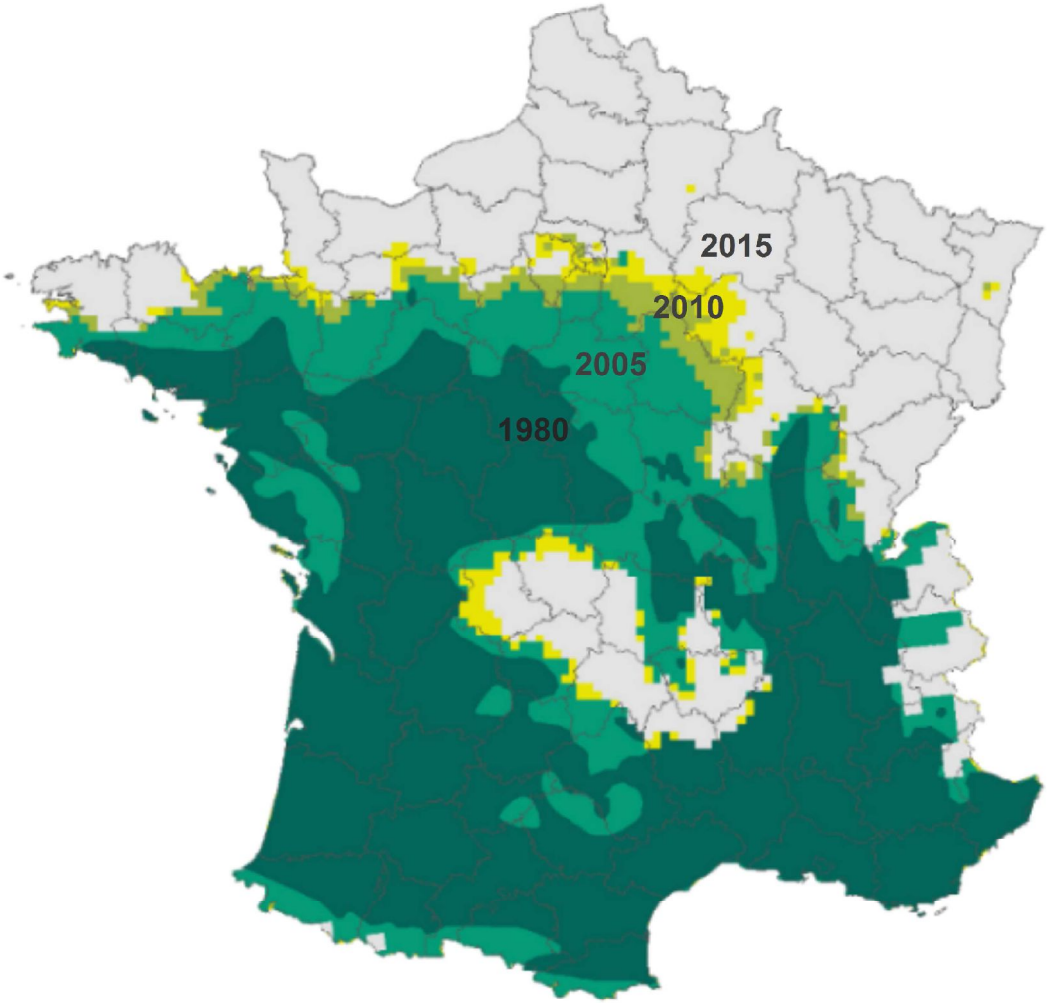
Detecting One-Hundred-Year Environmental Changes in Western China Using Seven-Year Repeat Photography

Huai Chen[1,2,3], Kaipu Yin[2], Haiyan Wang[2], Shenxian Zhong[2], Ning Wu[2], Fusun Shi[2], Dan Zhu[2], Qiuan Zhu[1,3], Weifeng Wang[3], Zhihai Ma[3], Xiuqin Fang[3], Weizhong Li[1], Pengxiang Zhao[1], Changhui Peng[1,3]*

1 Laboratory for Ecological Forecasting and Global Change, College of Forestry, Northwest Agriculture and Forest University, Yanglin, China, **2** Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu, China, **3** Department of Biology Science, Institute of Environment Sciences, University of Quebec at Montreal, Montreal, Canada

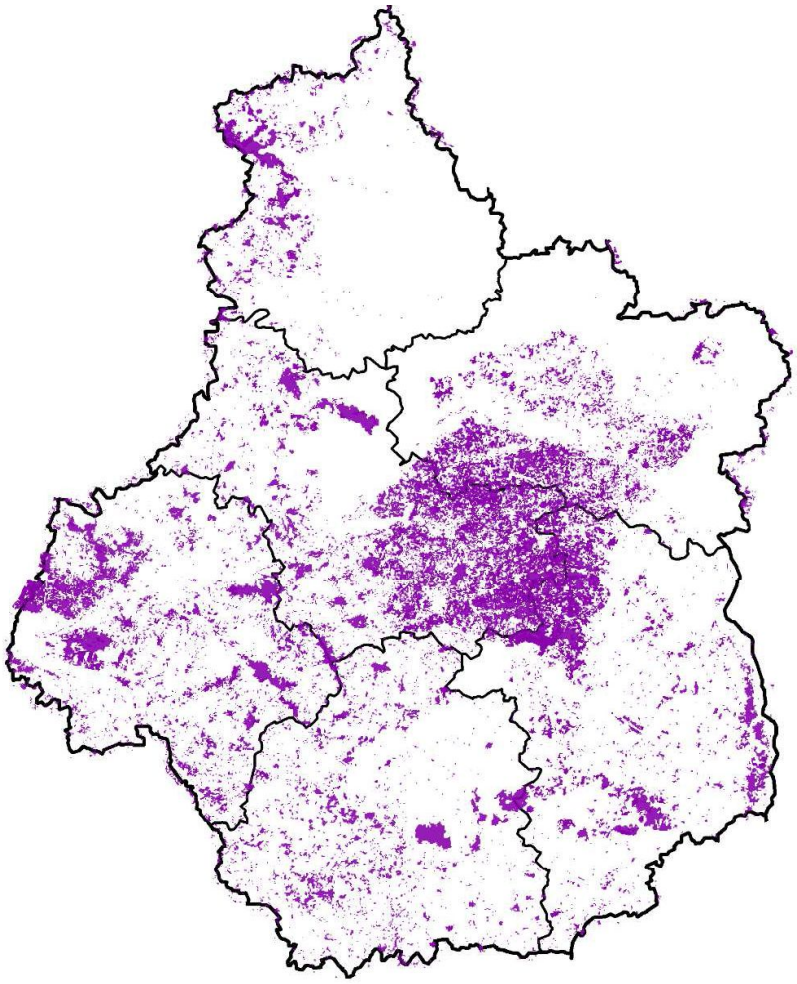
Une expansion vitesse d'expansion régionalement variable

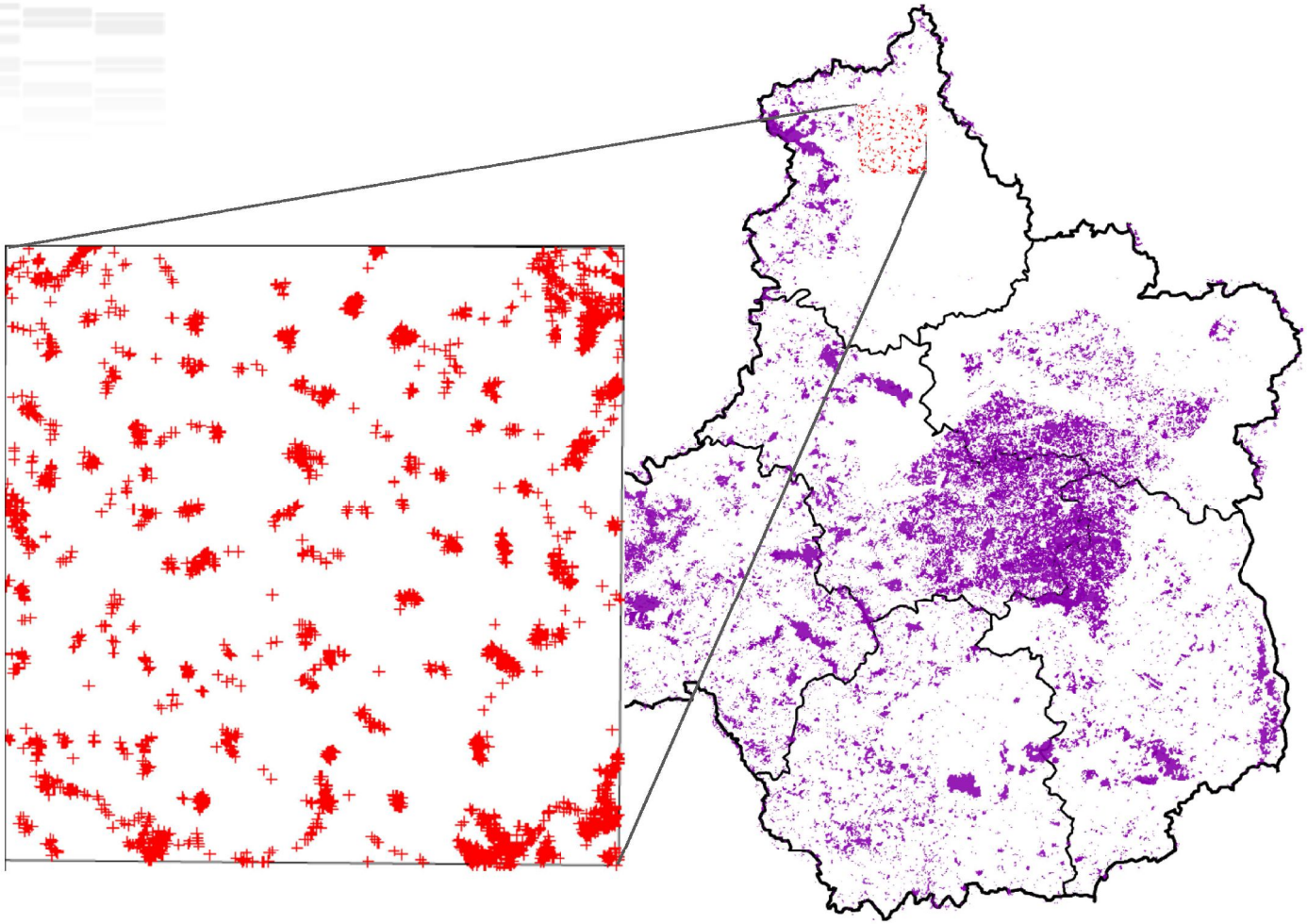
Une espèce en expansion depuis les années 1990 sous l'effet du réchauffement climatique



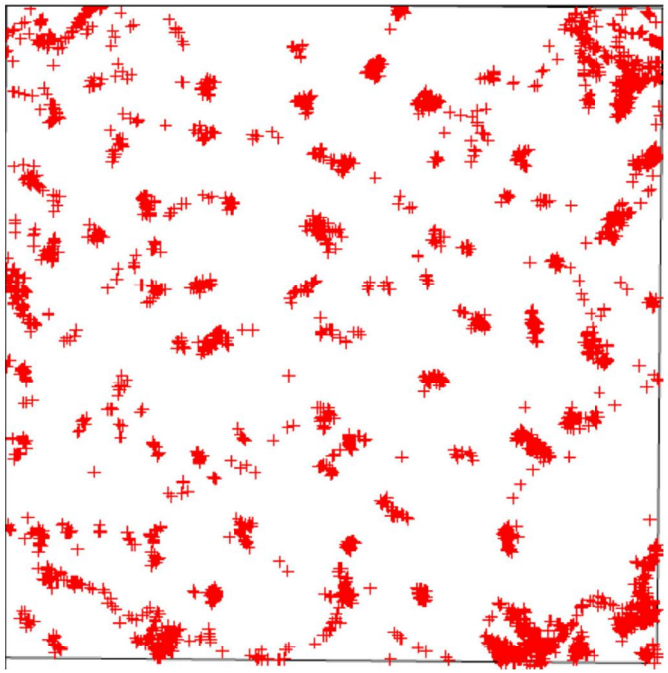
La processionnaire du pin, *Thaumetopoea pityocampa*

Cartographie des arbres-hôtes ... sans télédétection

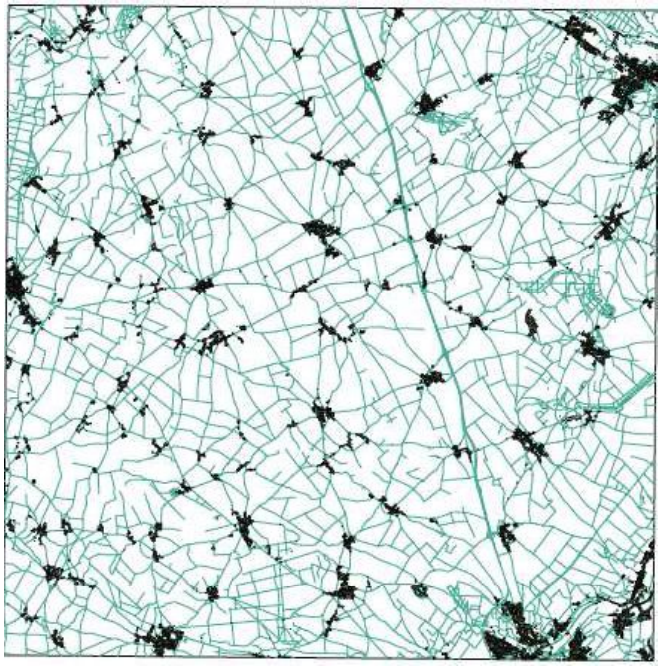


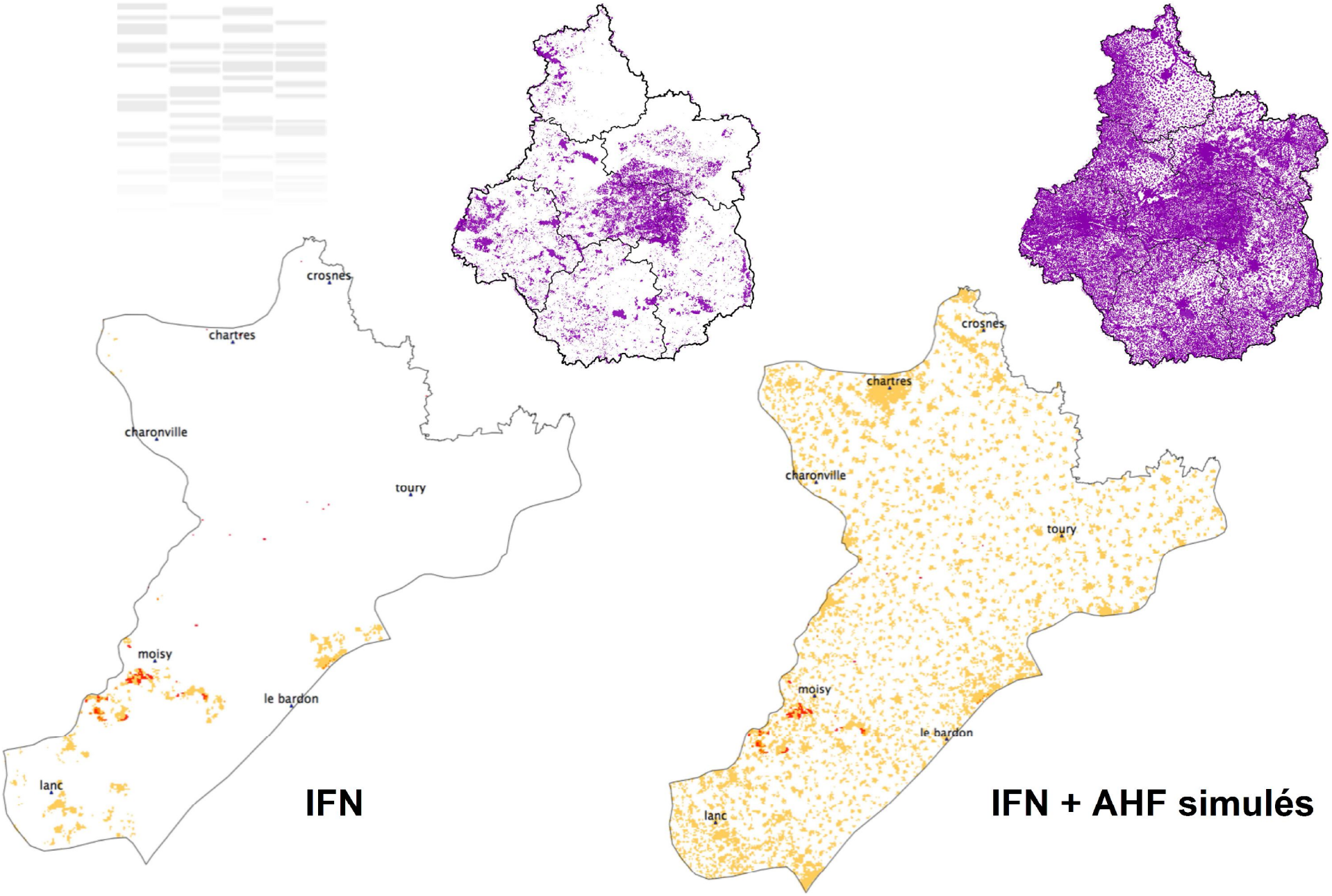


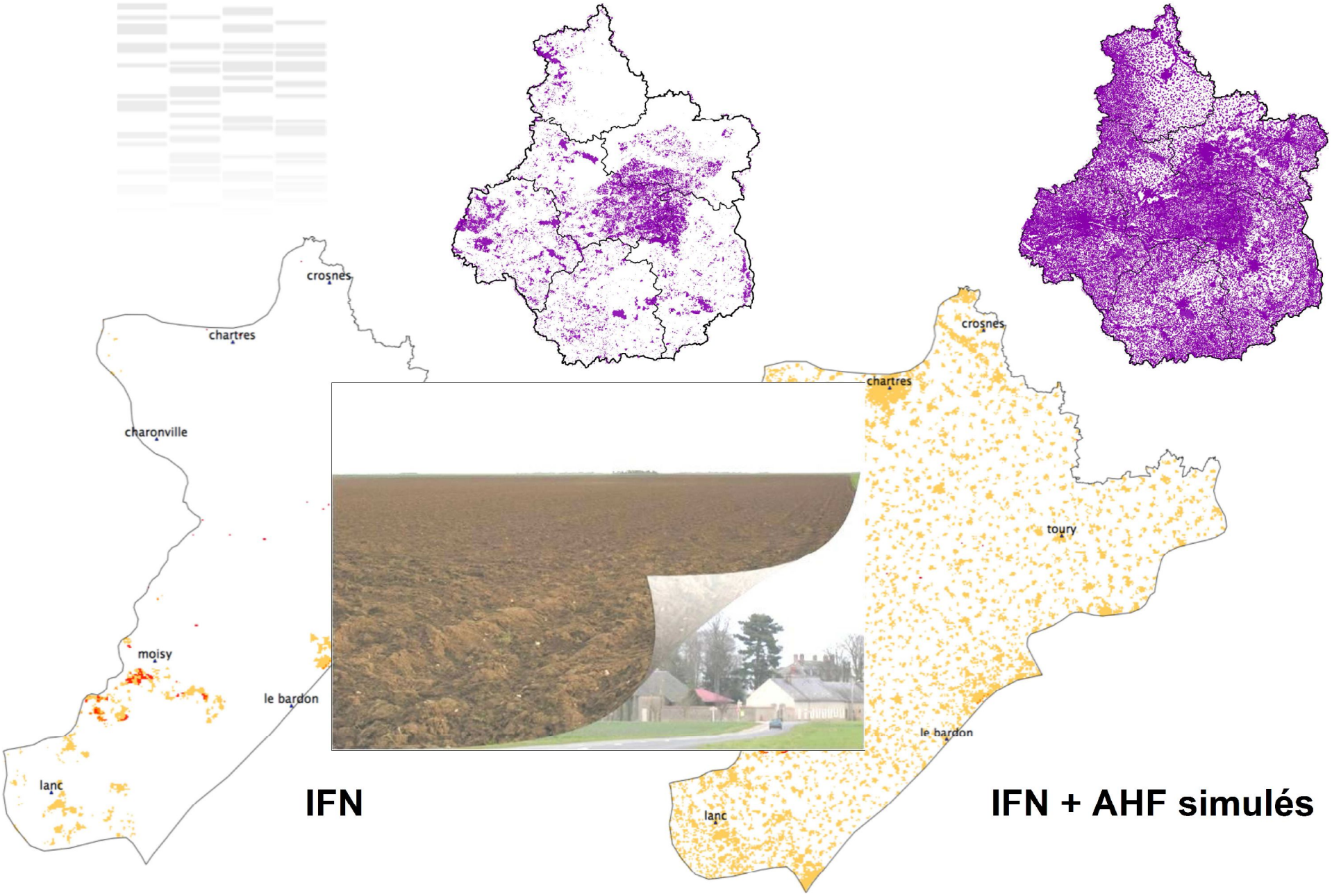
AHF hôtes



Routes et bâtis (IGN)




crosnes
chartres
charonville
toury
moisy
le bardon
lanc
IFN
crosnes
chartres
charonville
toury
moisy
le bardon
lanc
IFN + AHF simulés



IFN

IFN + AHF simulés

Automated Classification of Trees outside Forest for Supporting Operational Management in Rural Landscapes

Corentin Bolyn *, Philippe Lejeune, Adrien Michez and Nicolas Latte

Uliège-Gembloux Agro-Bio Tech. TERRA Teaching and Research Center—Forest Is Life, Passage des Déportés 2, BE-5030 Gembloux, Belgium; p.lejeune@uliege.be (P.L.); adrien.michez@ulg.ac.be (A.M.); Nicolas.Latte@ulg.ac.be (N.L.)

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Abstract: Trees have important and diverse roles that make them essential outside of the forest. The use of remote sensing can substantially support traditional field inventories to evaluate and characterize this resource. Existing studies have already realized the automated detection of trees outside the forest (TOF) and classified the subsequently mapped TOF into three geometrical classes: single objects, linear objects, and ample objects. This study goes further by presenting a fully automated classification method that can support the operational management of TOF as it separates TOF into seven classes matching the definitions used in field inventories: Isolated tree, Aligned trees, Agglomerated trees, Hedge, Grove, Shrub, and Other. Using publicly available software tools, an orthophoto, and a LIDAR canopy height model (CHM), a TOF map was produced and a two-step method was developed for the classification of TOF: (1) the geometrical classification of each TOF polygon; and (2) the spatial neighboring analysis of elements and their classification into seven classes. The overall classification accuracy was 78%. Our results highlight that an automated TOF classification is possible with classes matching the definitions used in field inventories. This suggests that remote sensing has a huge potential to support the operational management of TOF as well as other research areas regarding TOF.

Utilisation de données *Google Street View* pour cartographier la processionnaire du pin

… et de nouveaux outils de *monitoring* pour suivre sa phénologie à distance

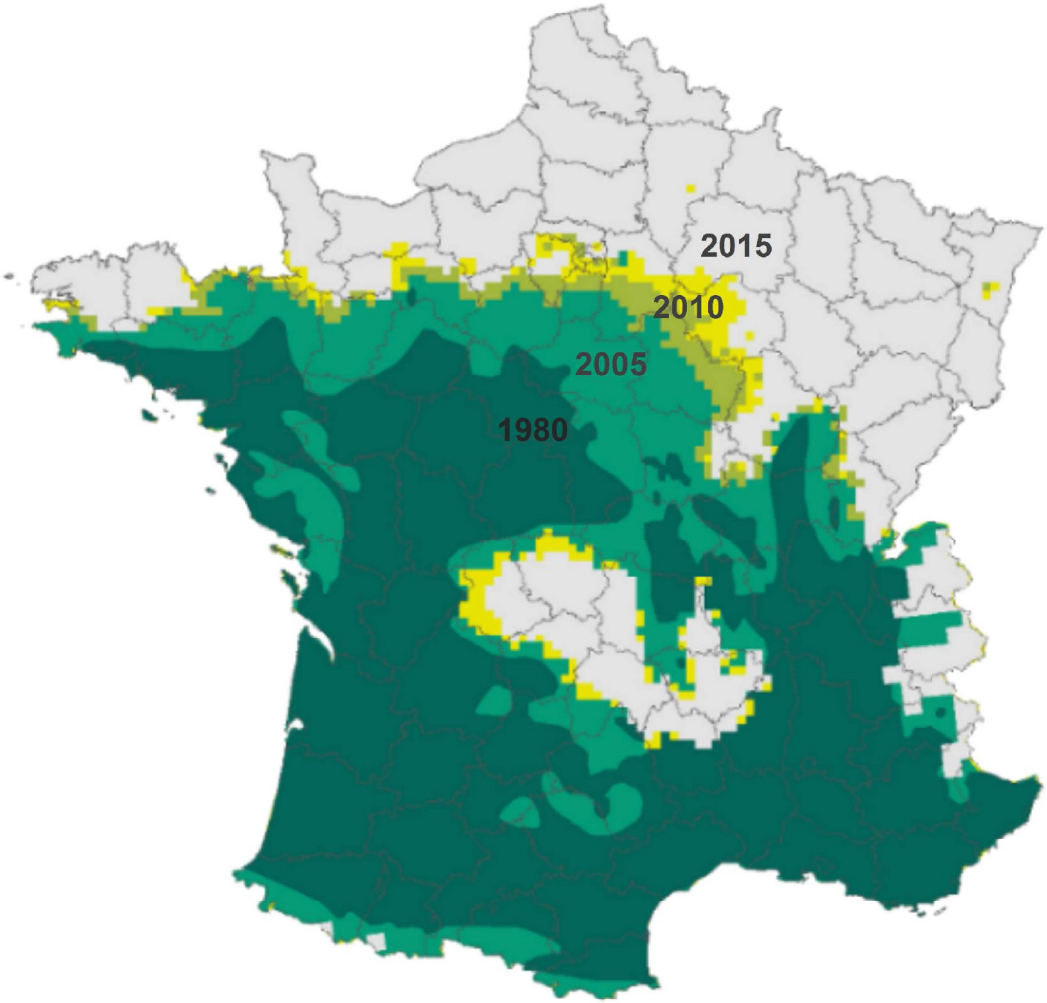
J. Rousselet
Unité de Recherche de Zoologie Forestière (URZF)
INRA Val de Loire - Orléans

J.-P. Rossi
UMR CBGP
INRA Montpellier

Journées Payote / Modelia « Deep learning, télédétecttion et paysage », Paris, 27/06/2019

Une expansion vitesse d'expansion régionalement variable

Une espèce en expansion depuis les années 1990 sous l'effet du réchauffement climatique



La processionnaire du pin, *Thaumetopoea pityocampa*

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

Phil. Trans. R. Soc. B (2010) **365**, 3149–3160

Review

Why does phenology drive species distribution?

Isabelle Chuine*

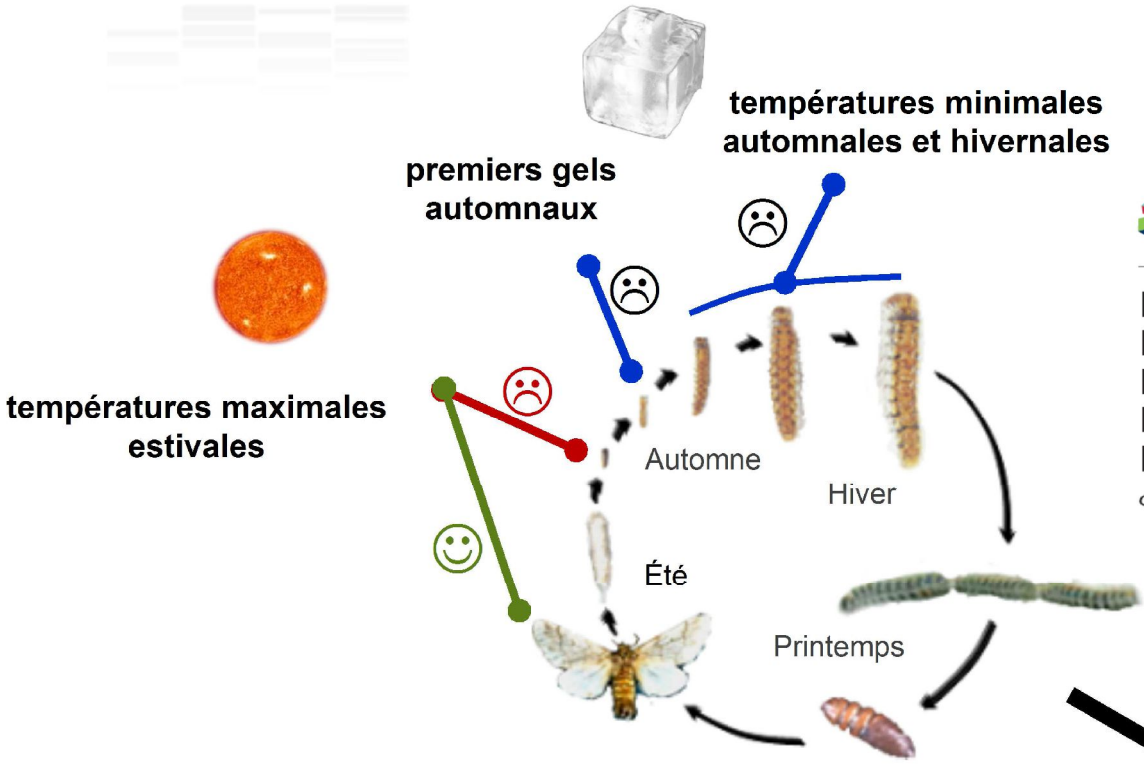
Centre d'Ecologie Fonctionnelle et Evolutive–CNRS
34293 Montpellier cedex 05, France

Stage-dependent physiological responses in a butterfly cause non-additive effects on phenology

Natalie J. Briscoe, Warren P. Porter, Paul Sunnucks and Michael R. Kearney

N. J. Briscoe (nbriscoe@unimelb.edu.au) and M. R. Kearney, Dept of Zoology, The Univ. of Melbourne, Victoria 3010, Australia. – W. P. Porter, Dept of Zoology, The Univ. of Wisconsin, Madison, WI 53706, USA. – P. Sunnucks, School of Biological Sciences and Australian Centre for Biodiversity, Monash Univ. Clayton, Victoria 3800, Australia.

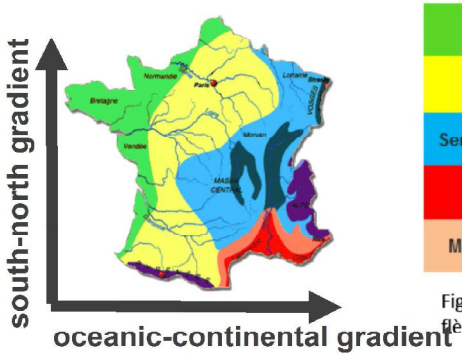
Variations phénologiques dans l'espace selon les climats



frontiers in Physiology
OPINION
published: 17 November 2015

Looking Beyond the Large Scale Effects of Global Change: Local Phenologies Can Result in Critical Heterogeneity in the Pine Processionary Moth

*Christelle Robinet *, Mathieu Laparie and Jérôme Rousselet*



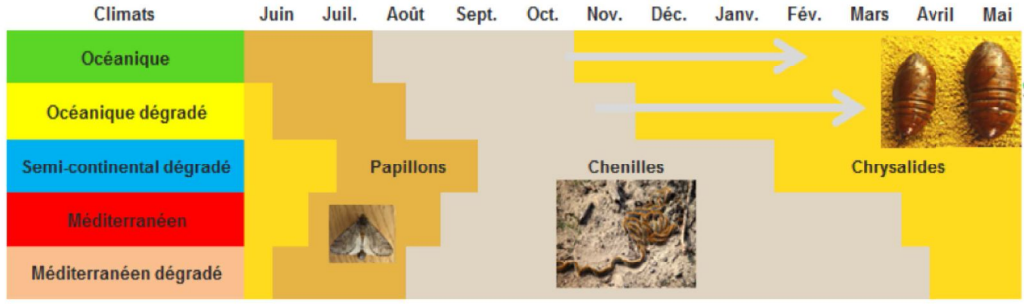
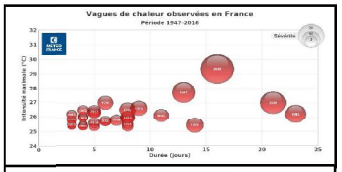
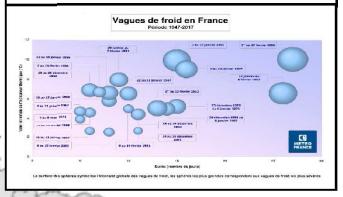
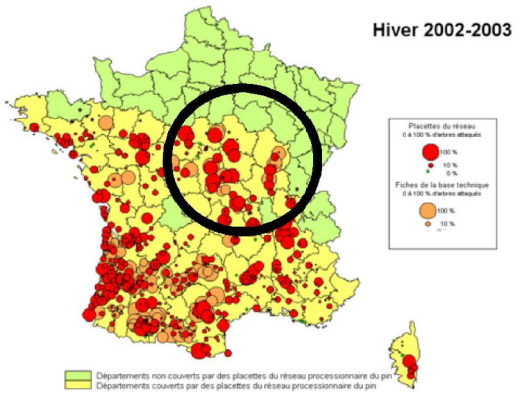


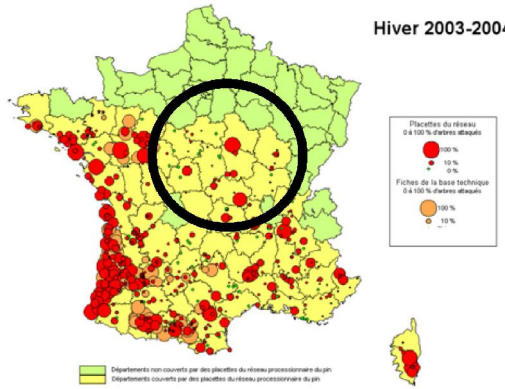
Figure 1: Tableau indicatif présentant la mise en correspondance du type de climat avec le cycle de vie de la processionna flèches indiquent la durée potentielle de la phase larvaire.

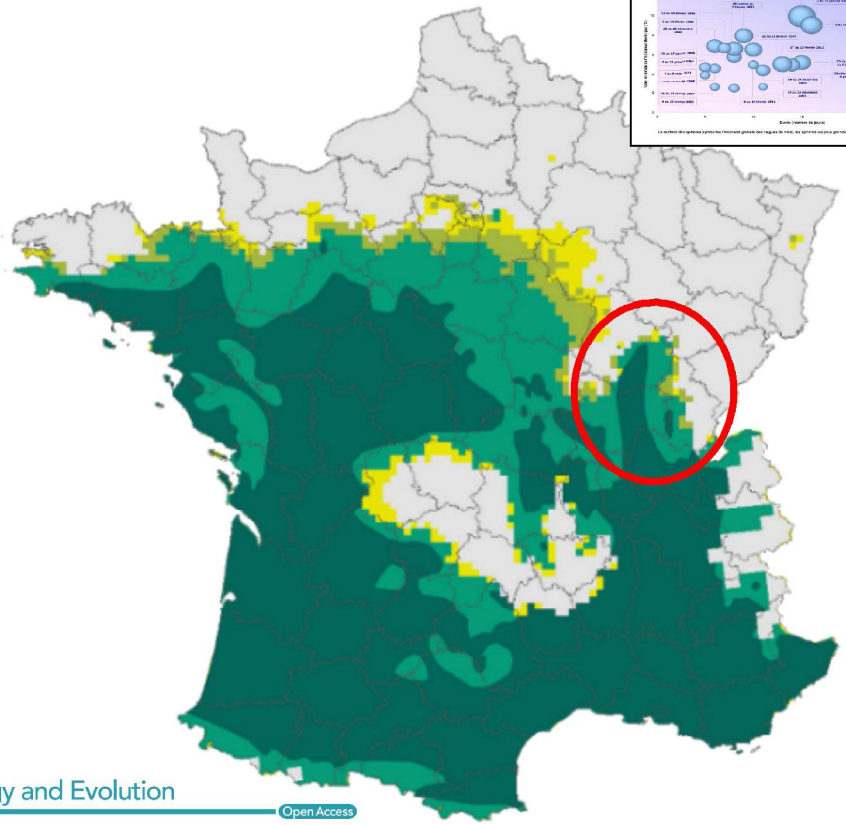
Canicule de 2003

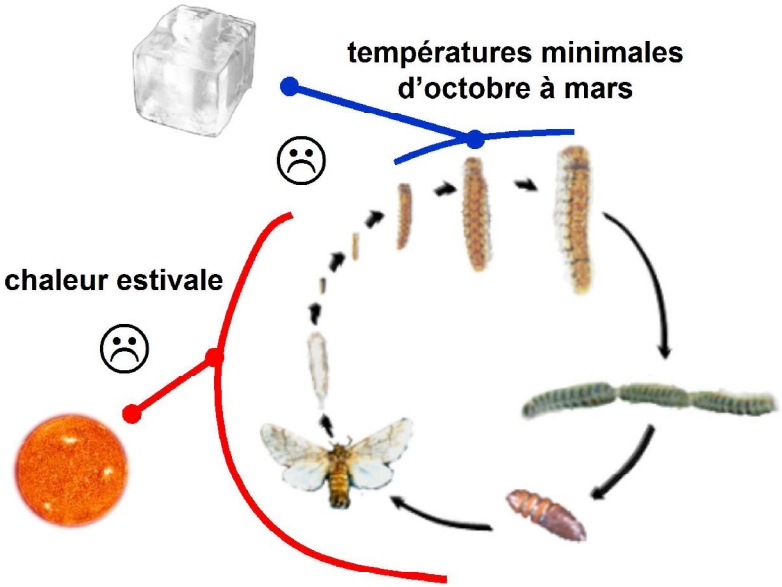












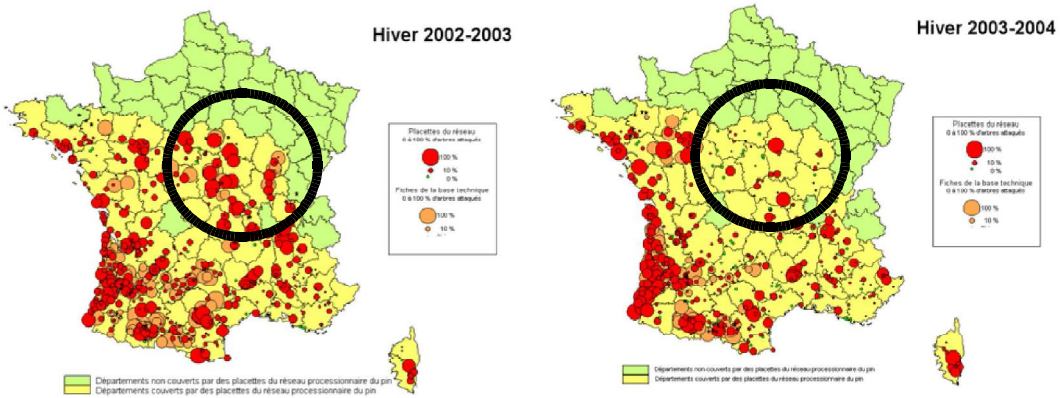
Ecology and Evolution Open Access

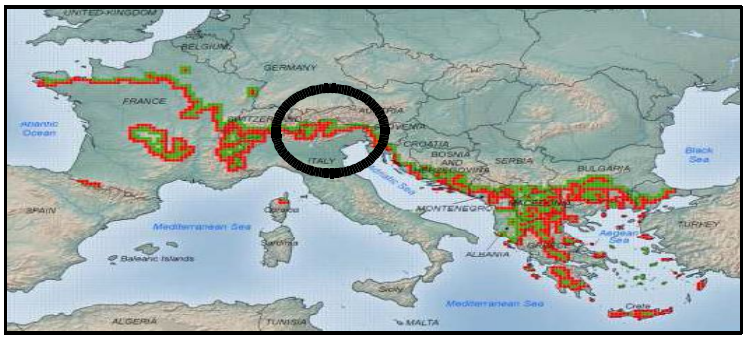
Are heat waves susceptible to mitigate the expansion of a species progressing with global warming?

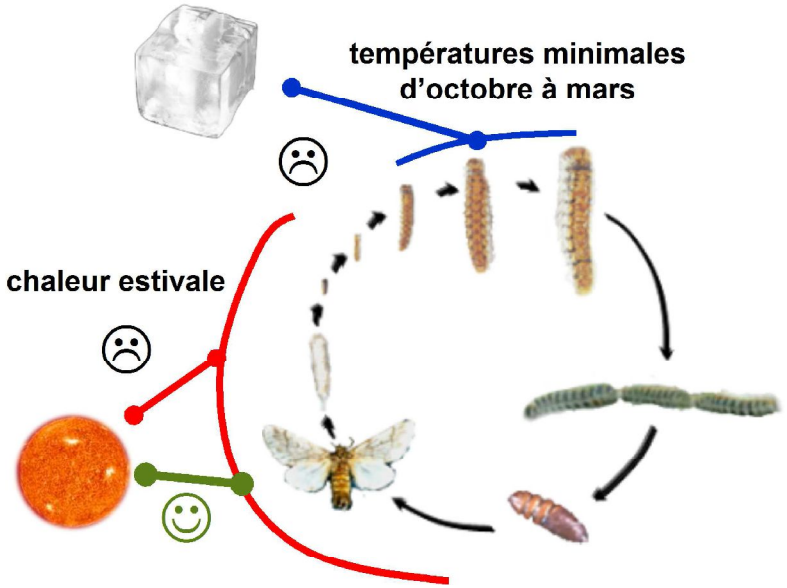
Christelle Robinet, Jérôme Rousselet, Patrick Pineau, Florie Miard & Alain Roques

INRA, UR633 Zoologie Forestière, F-45075 Orléans, France

Canicule de 2003







Global Change Biology (2006) **12,** 662–671, doi: 10.1111/j.1365-2486.2006.01124.x

A rapid altitudinal range expansion in the pine processionary moth produced by the 2003 climatic anomaly

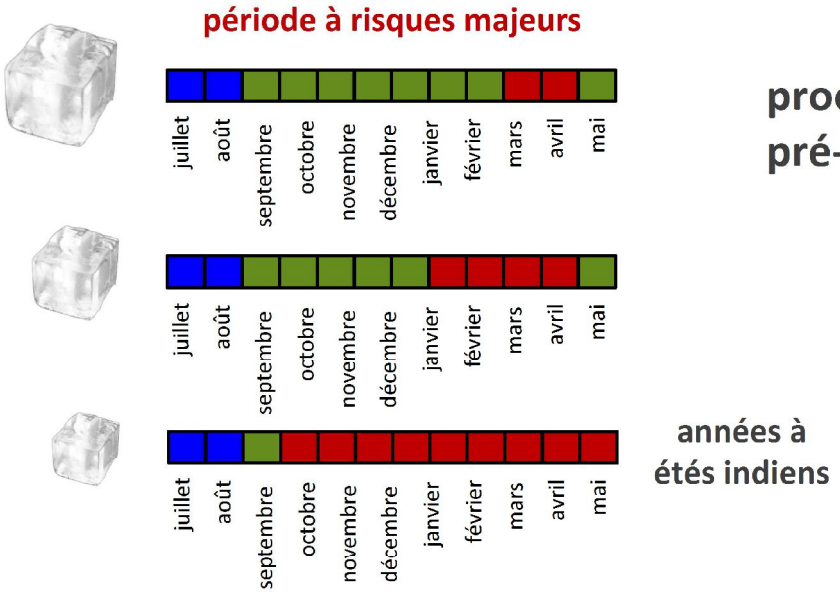
ANDREA BATTISTI*, MICHAEL STASTNY†, EMILIANO BUFFO* and STIG LARSSON‡
*Department of Environmental Agronomy – Entomology, University of Padova, Via Università 16a, 35020 Legnaro, Italy,
†Department of Ecology and Evolutionary Biology, Cornell University, Corson Hall, Ithaca, NY 14853-2701, USA,
‡Department of Entomology, Swedish University of Agricultural Sciences, PO Box 7044, S-750 07 Uppsala, Sweden

⇨ **même événement climatique = réponses différentes**

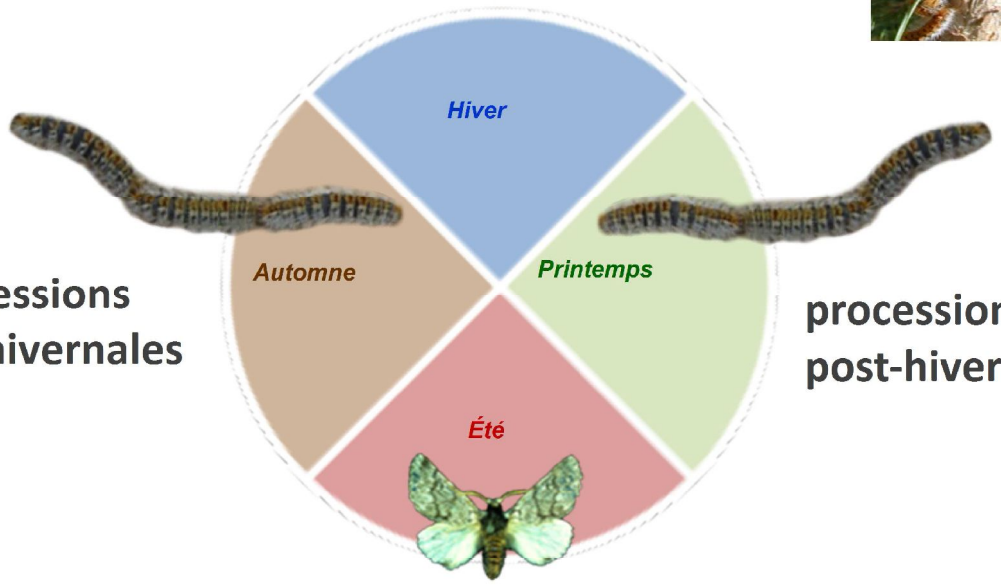
Vagues de chaleurs automnales

⇨ la PP en tant que modèle d'étude du dérèglement climatique

Processions précoces et phénologies "erratiques"



années à étés indiens



processions pré-hivernales

processions post-hivernales

⇒ accroissement des problèmes sanitaires

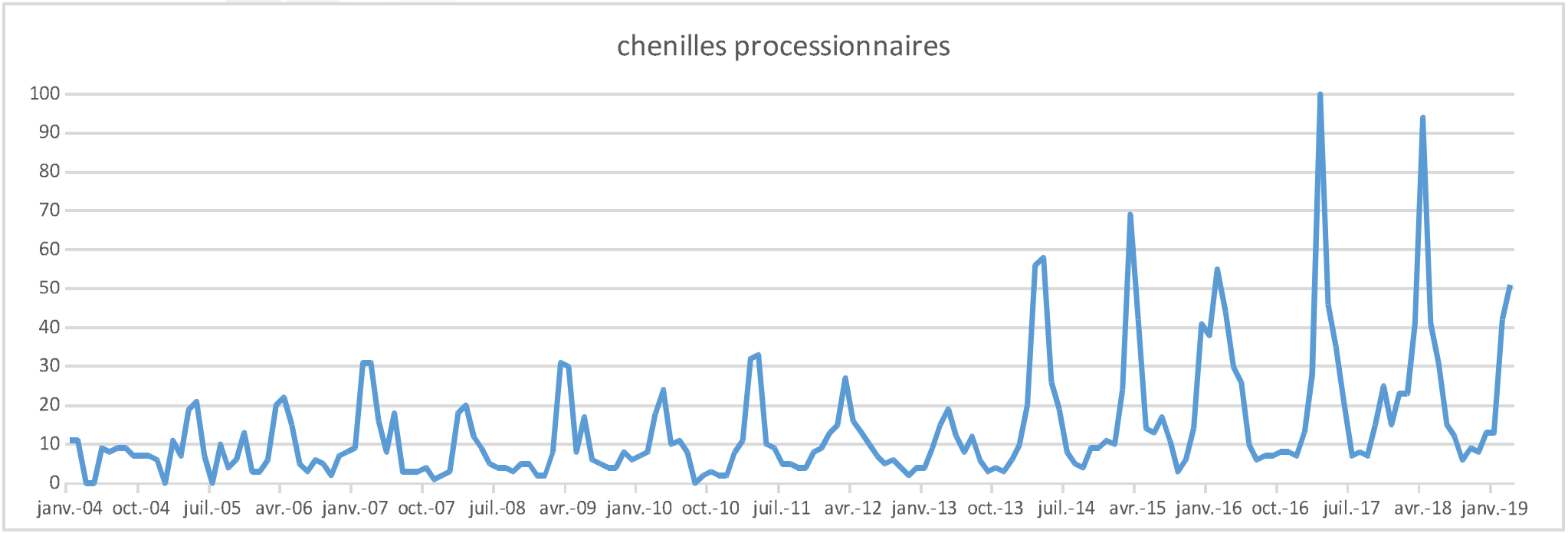
⇒ accroissement des échecs de lutte

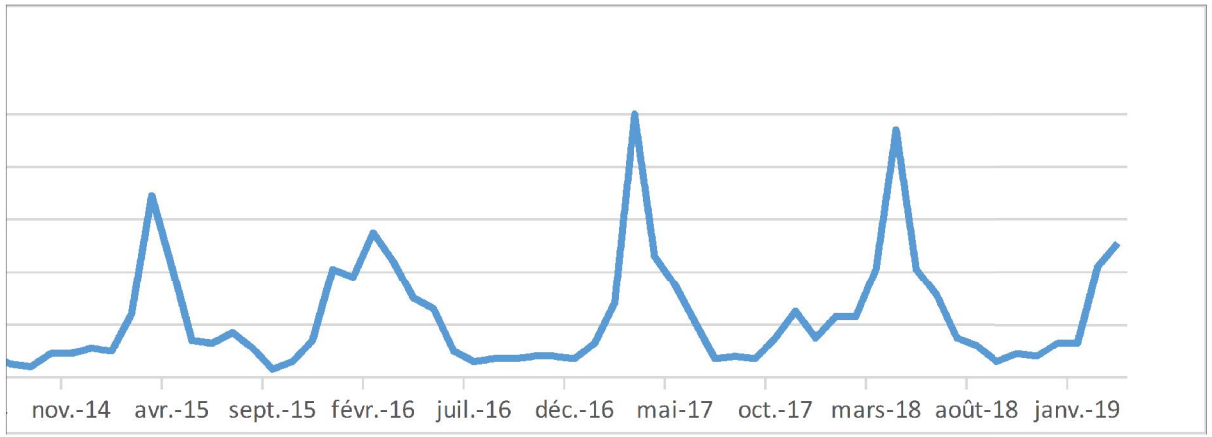
Phénologie de la processionnaire du pin

⇨ déclenchement de la lutte
⇨ alertes sanitaires

⇨ interrelation réponse distributionnelle et réponse phénologique au changement climatique?

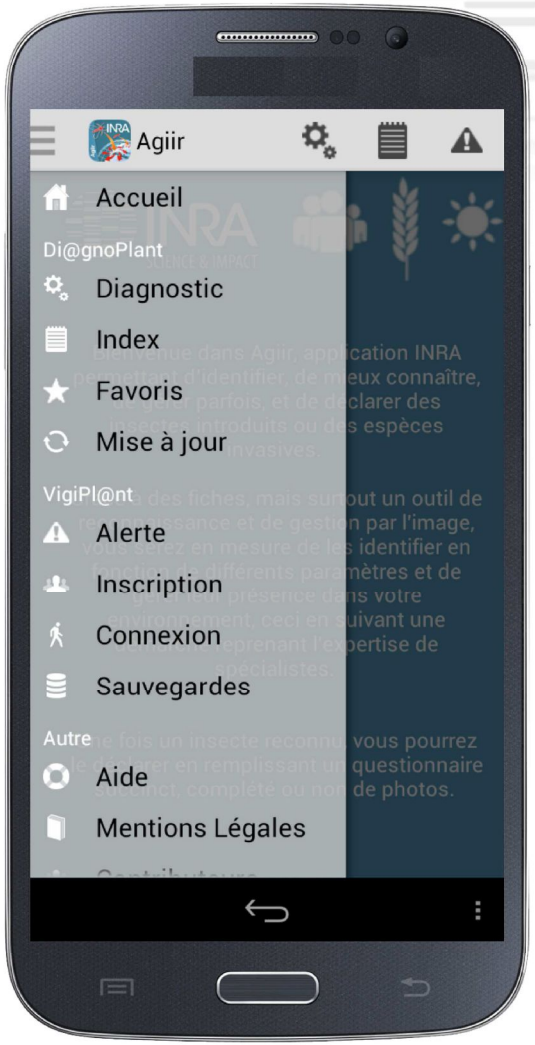
Google Trends

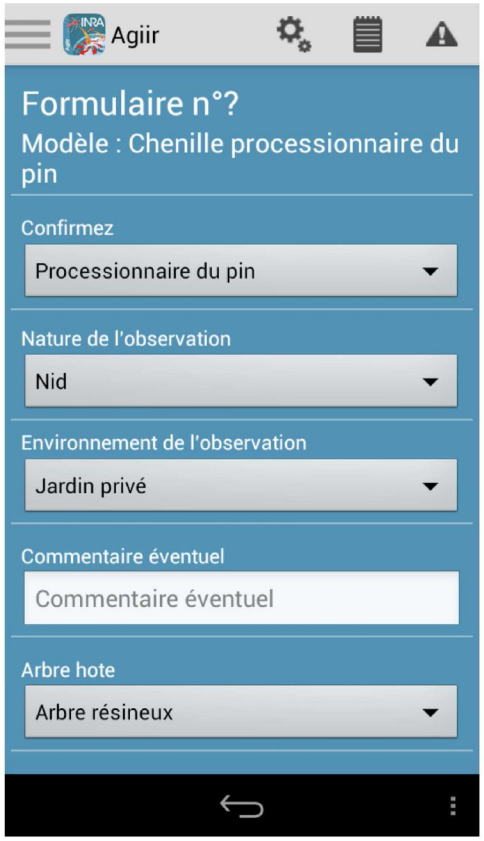




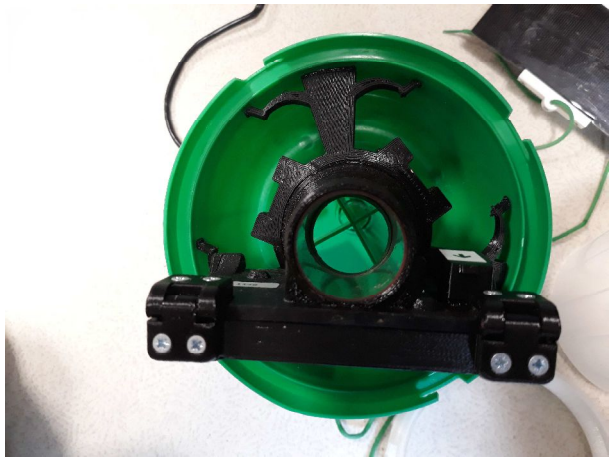
AGIIR : Alerter & Gérer les Insectes Invasifs et/ou Ravageurs

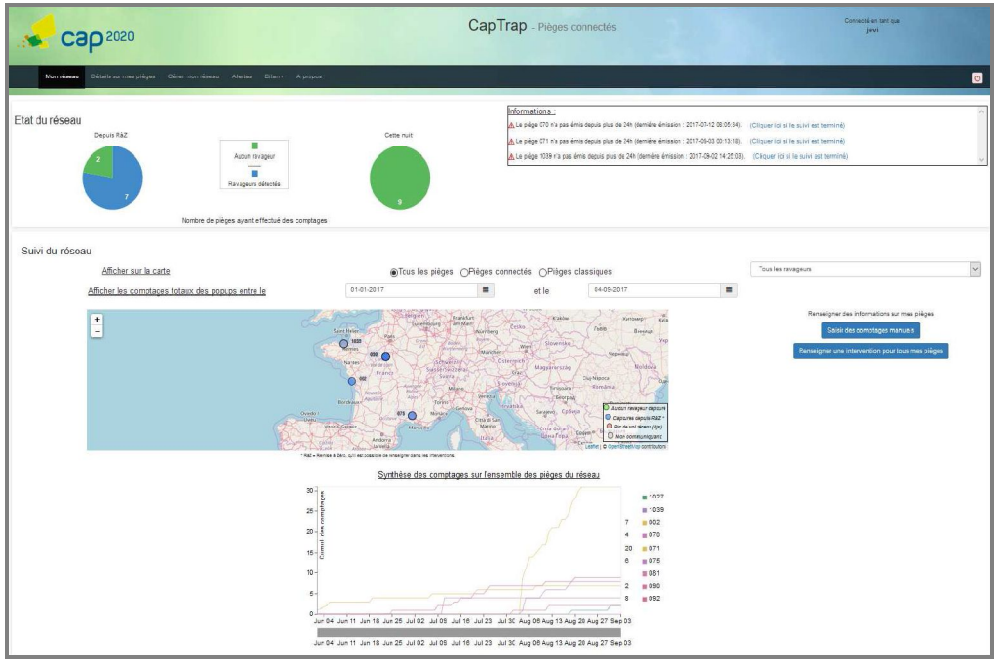
INRA SAVE BORDEAUX / UEFM PACA





Tools for Remote and/or Automated Phenological Surveys





cap 2020

monitoring à distance du vol des mâles

= *proxy* ponte

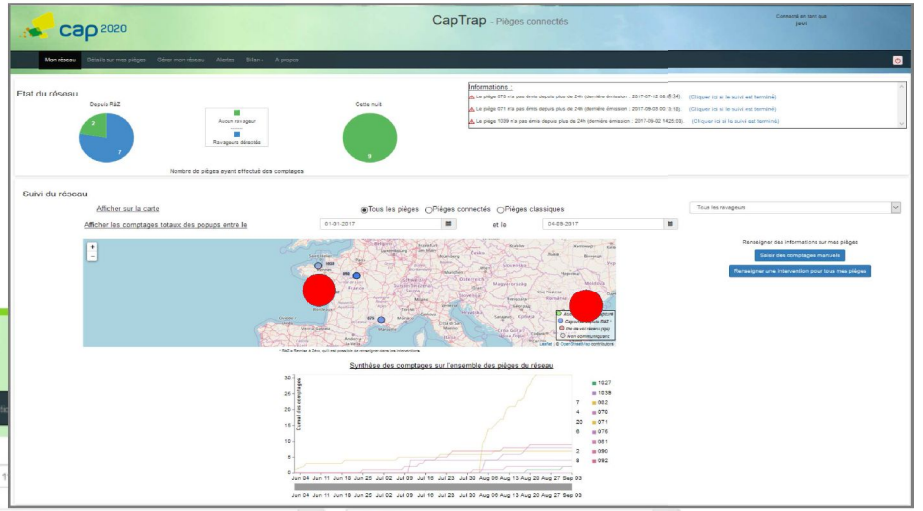
SIGFOX (low-bandwidth wireless network)

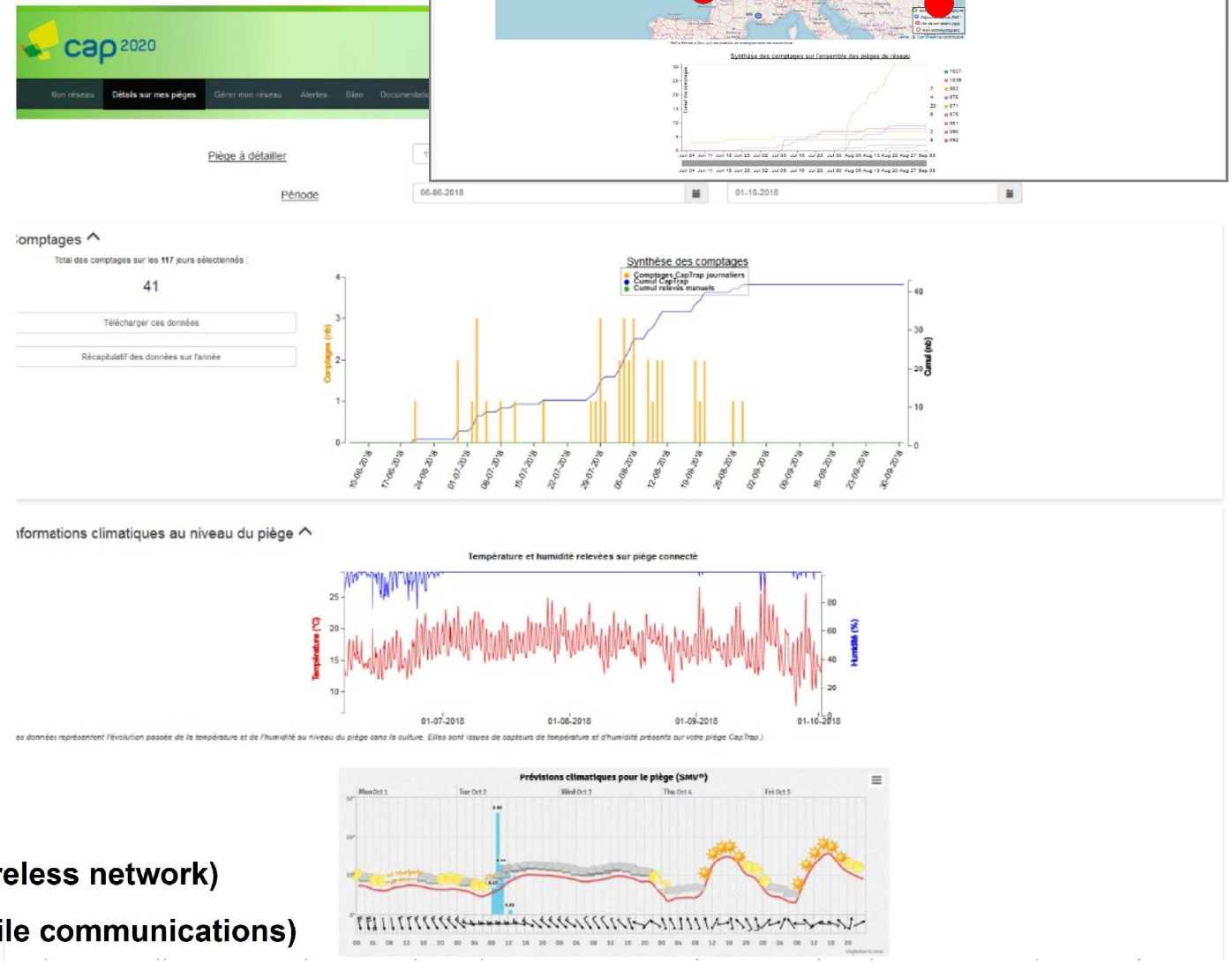
GSM (Global System for Mobile communications)

cap 2020

monitoring à distance
du vol des mâles

= *proxy* ponte

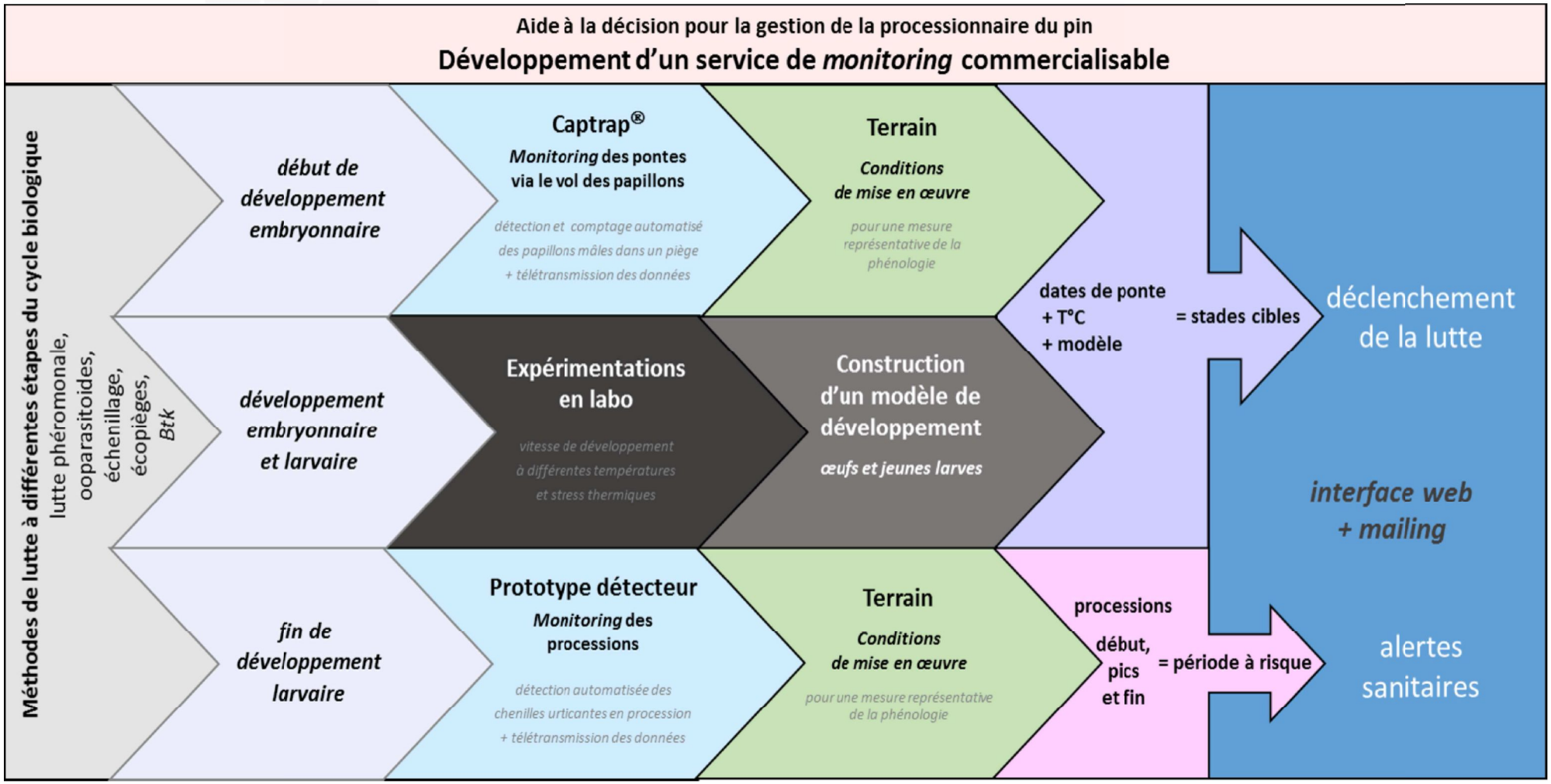




SIGFOX (low-bandwidth wireless network)

GSM (Global System for Mobile communications)

WEB-TRAPS


Aide à la décision pour la gestion de la processionnaire du pin
Développement d'un service de *monitoring* commercialisable
Méthodes de lutte à différentes étapes du cycle biologique
lutte phéromonale, ooparasitoides, échenillage, écopièges, Btk
début de développement embryonnaire
développement embryonnaire et larvaire
fin de développement larvaire
Captrap®
Monitoring des pontes via le vol des papillons
détection et comptage automatisé des papillons mâles dans un piège + télétransmission des données
Expérimentations en labo
vitesse de développement à différentes températures et stress thermiques
Prototype détecteur
Monitoring des processions
détection automatisée des chenilles urticantes en procession + télétransmission des données
Terrain
Conditions de mise en œuvre
pour une mesure représentative de la phénologie
Construction d'un modèle de développement
œufs et jeunes larves
Terrain
Conditions de mise en œuvre
pour une mesure représentative de la phénologie
dates de ponte
+ T°C
+ modèle
= stades cibles
processions
début, pics et fin
= période à risque
déclenchement de la lutte
interface web + mailing
alertes sanitaires