

Value and limits of citizen science in biodiversity monitoring

Citizen sciences are undergoing strong growth, a fact demonstrated by the session devoted to the topic at the 3rd French-language meetings on conservation biology (Le reveil du dodo III, 17-19 March 2009 in Montpellier) and the seminar titled Citizen science and biodiversity, held in Montpellier on 22-23 October 2009.

Marion and Frédéric Gosselin, engineer and researcher at Cemagref in Nogent-sur-Vernisson discuss the topic here with Romain Julliard, researcher at the MNHN bird-ringing project and who has managed a number of Vigie-Nature programmes requiring public participation (naturalists and amateurs) to collect the necessary data. The discussion successively addresses the history of citizen sciences, their advantages and limits, focussing on the assessment of biodiversity-conservation policies.

Why call on the general public to monitor changes in nature (for biodiversity, but also physiological phenomena as is the case for the seasonal observatory)?

Romain Julliard. Our primary goal is to have numerous observation points for species suitable for new scientific publications that would not be possible otherwise. For example, there are many scientific publications on butterflies, but not on butterflies on private premises, such as gardens.

Our second goal is to develop a means to raise public awareness and make observers change their perception of nature and biodiversity.

What is the history of citizen monitoring? Where is it the most developed?

Romain Julliard. Ever since there have been naturalists, amateurs have taken part in observations and naturalist organisations subsequently kept the networks of amateur observers. The new aspect of what is called citizen monitoring is that scientists have seized the initiative and propose protocols well suited to groups of volunteers.

In the Netherlands, the U.K. and English-speaking countries in general, people are very involved in social life, more than in countries with Latin cultures. Many

associations fill the role of public services in a vast array of fields. In the naturalist field and for all taxa, it is much easier to mobilise observers than in France.

The cultural differences are also manifested in the high degree of confidence that Anglo-Saxon observers place in the protocols and in the collective monitoring project.

In Latin countries, however, observers are wary and ask three questions before committing.

- Are they really interested in my contribution and not trying to sell something else?
- Is this a useful project ?

• Will I be of any use in this project? If other people can do just as well, the (potential) observer will avoid the commitment. That is perhaps one of the reasons why the Garden butterfly observatory (Observatoire des papillons de jardin, OPJ) is so successful. In addition to the initial motivation to learn about butterflies, observers have the impression that their garden, a private space, will supply data not available elsewhere.

Frédéric Gosselin. Is it linked with the notion of heritage?

Romain Julliard. Certainly for the OPJ, but it is not a systematic factor. The most important factor is to feel useful. That issue guided us in designing the upcoming photographic monitoring programme for pollinating insects (SPI-POLL). The protocol is to photograph, over a limited time period, species gathering nectar and pollen in a limited



📷 SPIPOLL :
a photographic
monitoring programme
for pollinating insects.

sector chosen by the observer, then to sort and perform morphospecies-level identification (see photo 1). The goal is to analyse:

- the richness and diversity of groups, for example, detect imbalances between Diptera and Hymenoptera as a function of an urban-agricultural gradient;
- systems of interaction between plants and pollinators (generalist or specialist species).

In the new project, contrary to the OPJ, the notion of heritage is not a factor, the observations can be made anywhere, in a garden or along a road, but we will be very demanding in terms of time and rigour. We think those demands may be the key to success, the observers will feel useful because not everyone can fulfil those demands. Plus, there is a fun aspect to the protocol (photographing, sorting, identifying) that is also an advantage.

Frédéric Gosselin. In other countries, do naturalist associations not hire more scientists to analyse and put to use their data? For example, the British trust for ornithology (BTO)?

Romain Julliard. BTO in the U.K. is a non-governmental organisation that receives considerable public funds. It plays the same role as CRBPO (Bird-ringing research centre) of the National museum of natural history in France, i.e. it coordinates ringing projects, manages all citizen-science monitoring efforts and carries out scientific research, works with universities, etc. In Holland, monitoring management is ensured to a large degree by naturalist associations and data analysis is carried out by a public statistics agency, similar to INSEE (National statistics institute) in France, but with a large environmental department. Given the size of the country, this organisation with a single analysis centre is sufficient.

Frédéric Gosselin. In France, Vigie-Nature is a programme of citizen-monitoring projects coordinated by the MNHN. What is the history of the programme?

Romain Julliard. The MNHN citizen-monitoring projects started with birds. CRBPO, the coordinator of bird ringing in France, always played a role in training and managing a network of volunteers (the ringers) and it was on the basis of this legitimacy and know-how that the STOC (temporal monitoring of common birds, the French breeding bird survey) project was launched in 1989. The STOC listening-stations project gathered a loyal network of observers in addition to those of the STOC ringing project. There are many amateur ornithologists and even with just a small percentage, the number of observers is sufficient. Observers were recruited individually and local associations took over management.

Other citizen-monitoring projects have been set up since 2005, some with naturalists.

- The butterfly-monitoring project (temporal monitoring of Rhopalocera in France - STERF), based on a network of naturalist observers, an initiative of the president of the Lepidoptera association of France. This is the best monitored group in Europe after birds. The observers in this network are difficult to mobilise, there are currently about 50 observers and 100 sites are monitored. Perhaps because naturalists are, in general, sceptical as to the usefulness of monitoring common species, for which the protocol does not foresee the monitoring of flag species. We are again confronted with the three questions that hinder citizen sciences in Latin countries.

- The bat observation project, in conjunction with SFEPM (French society for the study and protection of mammals).

- Vigie-Flore, launched in 2009 as a partnership with the Tela-Botanica association for network management. Others have been set up with the general public.

- The Garden butterfly observatory (OPJ). The association called Noé Conservation had a project called "Butterflies and gardens, linked lives", to raise awareness of amateur gardeners for the environment via butterflies.



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► The MNHN offered to add a citizen-science project. Building on the attractiveness of butterflies, the goal of the project is to gradually expose the observers to a scientific approach, i.e. learn to identify butterflies, learn their ecology (e.g. the existence of migratory butterflies), understand the presence of butterflies as a function of how the garden is managed.

- The snail project, a public observatory proposed to the OPJ network. The link with gardening practices (mowing, pesticides) is even clearer for snails than for butterflies and snail distribution can vary in a single garden, depending on the local micro-habitats. With snails, it is also possible to have schools participate in the monitoring project because observations are essentially from February to November, contrary to butterflies which are most numerous in the summer, during school vacation.
- And soon the photographic monitoring programme for pollinating insects (SPIPOLL) (see photo 2).

How do you select the taxa to be monitored?

Romain Julliard. Selection of the taxa monitored in Vigie-Nature is opportunistic and pragmatic. We monitor taxa for which a network of observers can be easily mobilised and a partnership is possible with an organisation that can take on network management. We do not select a species because it would be a good indicator for the rest of biodiversity. During data analysis, it turns out that some are indicators of changes in other species. But the fact is they are indicators because we monitor them and we have nothing better!

Marion Gosselin. Does citizen monitoring deal exclusively with common species?

Romain Julliard. In Vigie-Nature, yes, we intentionally address ordinary biodiversity for a number of reasons. First, because we are looking for originality in our scientific publications and rare species are heavily monitored

by associations and university researchers. Also, because the functioning of ecosystems and the resulting ecosystem services depend to a large extent on common species.

Marion Gosselin. Common species also have the advantage of being easy to observe and the source of abundant data, which in turn means greater statistical power for data analysis.

Romain Julliard. Monitoring is carried out on a species when it is easy to determine or on a group of species, e.g. according to morphological criteria, if determination is difficult.

Marion Gosselin. How can data from a "group of species" be analysed when the species in a group have such different ecologies?

Romain Julliard. That is the case for the "small blue butterflies" in the OPJ, a group comprising highly diverse species. Of course, we cannot analyse the impacts of gardening practices on the group. The data for the "small blues" is used simply to calculate the number of species or the overall abundance of the butterfly community in a garden.

Marion Gosselin. It is thus necessary to be aware of what information the data can provide and what they cannot provide because they are not designed for that purpose.

Romain Julliard. We are aware of that and try to explain it, notably to naturalists who are often frustrated by certain aspects of the protocol, e.g. grouping of species that are difficult to distinguish.

Does monitoring elicit a real and durable interest in scientists and the public?

Romain Julliard. We observe both a strong mobilisation on the part of the public and "losses" over time. Each year, 40% of the OPJ observers leave the programme. But they are replaced by new volunteers and the total number of observers is stable from year to year. That implies management work, i.e. recruiting new observers, but also proposing new activities and tools for the project. The long term ("we will have results in ten years") does not motivate observers. What encouraged observers to count birds each year at the same place for the STOC project, as foreseen by the protocol, was the possibility of variations from one year to the next, which made them want to understand what had happened, given that nesting birds are territorial and if they are heard somewhere, it is because there are sufficient resources. It is more difficult to keep botanist observers for Vigie-Flore because there is little chance that flora will change significantly from one year to the next (see photo 3). Once the description has been carried out the first year, people become bored.

Are there not strong "observer effects" and risk of error if observers are beginners? If so, how does one correct that and analyse the data?

Frédéric Gosselin. To fill out the question, is it possible to calibrate the data from each observer, even integrate species-detection probability by observer for data analysis?

Romain Julliard. For the OPJ, it is the large number of observations that makes it possible to statistically compare situations, e.g. the effect of practices on community

diversity or the location between town and country. But the OPJ was not designed to monitor temporal changes in the abundance of butterfly communities on the national level. It was designed for synchronic comparisons. Diachronic use of the data, i.e. the temporal change, is more limited. It is limited to the observation point, the garden, with two sources of bias, i.e. improvement in practices and in the observers, which are linked. Though sources of bias, they are improvements that we encourage because one of the goals of the OPJ is greater awareness. That does create a real problem in interpreting the observed trends. In the end, the contrast between the trends observed by the OPJ and those observed by other networks, e.g. STERF, is more useful than assuming the OPJ is a reference for butterflies in France. The OPJ was not designed to measure the health of butterfly communities in France. Its purpose is to detect the relationship between gardening practices and the diversity of butterfly communities in gardens.

Frédéric Gosselin. But as you noted, there is a bias due to the fact that the more observers are aware of the need for practices favouring butterflies, the more they will pay attention to detecting butterflies. The probability of detection thus differs as a function of the practices and correspondingly biases the analysis of species diversity.

Romain Julliard. We are thinking about integrating the "observer seniority in project" parameter in the analysis, first to correct the bias, secondly because it is interesting to analyse the relationship between observer seniority and

declared gardening practices or the frequency of observation. It is already clear that more long-standing observers detect more species than newcomers.

Marion Gosselin. Is there information available on the percentages of error (species not detected, incorrectly identified) in citizen-monitoring projects?

Romain Julliard. We try to estimate the error rate to reassure ourselves, but the estimation is not used to correct the data. For the 2008 OPJ survey, the photos sent in by observers of butterflies gathering nectar revealed an identification error rate of 5%. The rate is identical for false positives (species detected in abnormal places or months).

Marion Gosselin. The OPJ data are not intended to monitor changes in the abundance of butterfly populations in France, but are they used to draw up species distribution maps?

Romain Julliard. That is not in fact the goal. Distribution maps are drawn up, but above all to validate data quality, to make sure that the distribution indicated by the data corresponds to what we know, i.e. there are no abnormal location data. It is a bit risky because we are accused of drawing up distribution maps with inadequate data. For the OPJ, it will be difficult to do more than the analyses on gardening practices and the urbanisation gradient with the count data alone. The next step will be to propose experiments to the observers, e.g. a change in practices.

How can the representativeness of samples be controlled for a given territory, when the observation points depend on where the observers live?

Marion Gosselin. If the goal of monitoring is to detect differences in diversity of species assemblages (a function of gardening practices for OPJ or depending on the type of environment, e.g. gardens, along roads or rail tracks, meadows, for the pollinator observatory), we need a balanced sample over the studied gradient, i.e. the garden-practices gradient or the urbanisation gradient. How can the representativeness of samples be controlled when the observation points depend on where the observers live (situation for the STOC) or on the willingness of the observers (situation for the pollinator observatory)?

Frédéric Gosselin. The same questions arise if the monitoring goal is to assess public policies, e.g. monitoring of species of EU interest to assess the effectiveness of the Natura 2000 network. The sampling technique must take the goal into account. Is there a type of post-stratification? Over which gradient(s)?

Romain Julliard. For the OPJ, there is post-stratification. We take advantage of the great number of observation points to create gradients a posteriori based on the urbanisation level where the gardens are located, regional differences and on the declared practices in the gardens (mowing, use of pesticides, composting, etc.). Then, similar to the STOC, we analyse how the abundance and diversity of the observed species vary as a function of the environmental gradient. For the STOC, the representativeness of samples is ensured because the observation points are indeed near the homes of the observers, but selected randomly in the neighbourhood.

④ Floristic survey in mountain.



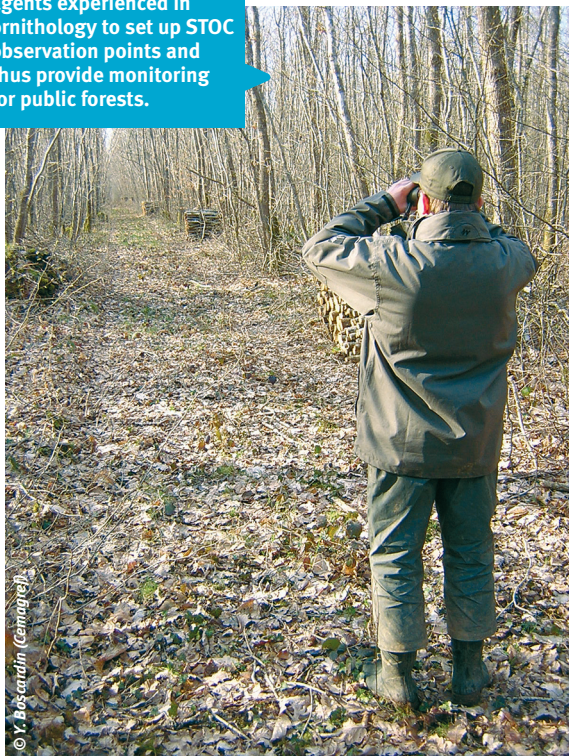
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► **Frédéric Gosselin.** Random selection is important, but does not guarantee that the results are representative of the situation in France. Certain regions are clearly undersampled because the observation-point density in each region depends on the geographic distribution of the voluntary observers. How can the differences in sampling effort be corrected between regions?

Romain Julliard. Indeed. For example, the French regions Aquitaine and Centre have fewer observation points than other regions. But we can assess representativeness and take it into account. There are two statistical rationales when calculating an average. Either we assume that each point is measuring the same thing, with a variance, in which case there is no use in weighting by the number of points in each region, or we assume that there are strong regional variations and that the observation points in different regions are not measuring the same thing, in which case weighting is necessary. For monitoring on the national level, we assume that the studied phenomenon is the same in all regions.

Frédéric Gosselin. Yet the National forest inventory (IFN), in assessing forest resources nationally, specifies for each plot the probabilistic weight according to which it was drawn at random and that is used in the analyses. They assume that there are differences between regions. Similarly, in 1994 in the U.K., ornithologists changed their observation protocol which previously focussed on the southern part of the country. But the results after 1994 revealed that changes in the North and South differed, which indicated that the prior sampling, which was not spread evenly over the country, was not representative.

📍 The National forestry agency asks its agents experienced in ornithology to set up STOC observation points and thus provide monitoring for public forests.



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Would it be possible to set up mixed networks, professional and amateur, where the professionals would fill in the holes in the sampling network?

Romain Julliard. That is already the case when entities want to set up STOC-compatible monitoring in a particular territory where they operate. For example, regional councils fund associations to fill out the STOC sampling network in view of setting up a regional observatory, or the National forestry agency asks its agents experienced in ornithology to set up STOC observation points and thus provide monitoring for public forests (see photo 4).

Marion Gosselin. But these additions are random, they depend on the willingness of local entities. There is no real organisation to improve sample representativeness on the national level.

Or would a "professional" network be possible to assess the effectiveness of public policies for biodiversity protection?

Marion Gosselin. We have seen that monitored taxa are selected opportunistically and not because there is a political will on the national level to monitor taxa because they are representative of biodiversity or because they are threatened in the current context of biodiversity erosion due to anthropogenic disturbances.

Frédéric Gosselin. But there is ambiguity in the public debates and in how the public agencies use monitoring projects. They use the data, because they are the only data available, letting people think, and perhaps thinking themselves, that the projects were designed from the start to monitor changes in biodiversity in France.

Marion Gosselin. With the risk that politicians will be satisfied, thinking that national biodiversity monitoring exists in France, when in fact many taxa and types of environment are not covered by current projects.

Romain Julliard. Yes. But we must remain realistic. An ideal protocol does not exist to monitor even a single taxonomic group such as birds on the scale of a country with such varied environments as France, there is not even one protocol that is better than the others. In addition, pragmatic aspects often outweigh the rest. For example, it would certainly be worthwhile to have a national monitoring programme for earthworms, given their importance for ecosystem functioning, but practically speaking, it is very difficult.

Marion Gosselin. Is there a chance of seeing politicians provide serious funding for a "professional" network?

Romain Julliard. I do not know. The other not very logical aspect of existing monitoring systems is the preponderance of birds. We are now working with the Agriculture ministry on a biodiversity observatory for farms. Birds would appear to be an unavoidable taxon in the observatory even though they are not organisms whose home range is suited to analysis on the scale of a farm.

Is monitoring seen as a major issue by decision-makers and society in general?

Romain Julliard. We must admit that biodiversity is not perceived by society as a major issue. Scientists carry out monitoring and their results are not contested. If biodiversity were to become an issue because it questioned the practices of certain groups, we would enter a more turbulent period.

Frédéric Gosselin. But there are laws and national commitments to protect biodiversity...

Romain Julliard. For now, the laws concern primarily protected species or zones.

Marion Gosselin. And we have not come up with the means to assess their effectiveness.

Romain Julliard. In the CNPN (National council for the protection of nature) commission, for example, we study impact-study files and compensation proposals for development projects (e.g. a road) and it is striking to see that there is never an assessment a posteriori of the measures taken (the compensation work). Checks are run simply to make sure the work was done, but assessments on the effectiveness are very rare and almost never contribute to our knowledge.

Marion Gosselin. France must periodically monitor conservation of the habitats (and of the species that live there) protected by the Natura 2000 network. Are there any plans to use Vigie-Nature data to that end?

Romain Julliard. Not for the time being, for organisational reasons. The absence of a shared protocol for all sites led us to align our efforts on the sites with the least data in order to merge and analyse the results.

Are the protocols consistent from one country to another?

Romain Julliard. In order to share the data from citizen monitoring, we obviously work a great deal with other countries. In Europe, there is a highly structured network for birds and for butterflies. The protocols have not been standardised by the countries, but they are compatible. For butterflies, they are in fact standardised, but much less so for birds, e.g. transect lines in the U.K., listening stations in France.

Frédéric Gosselin. As far as I am aware, the countries share the estimators of the overall trends observed, similar to a meta-analysis based exclusively on published average data, but not the individual observation data that could be used for more in-depth analysis.

Romain Julliard. That is the case due to the available resources for database entry and export that differ from one country to another. The more in-depth analysis that you mentioned takes place case by case, when opportunities for collaboration present themselves.

Frédéric Gosselin. What links can be established between biodiversity data and the ecological variables that can explain the observed variations? I ask the question in light of the situation with the spotted owl. No efforts were made to ensure that all the monitoring sites for the owl population include standardised habitat measurements to see if it is effectively the quantity of old forests that determines owl

populations. Yet two or three limited studies addressed the issue of the favourable habitat quantity and questioned the validity of a linear relation between the favourable habitat quantity and owl populations. In which case, management efforts to mix very old and younger forests could be optimal for owls, whereas today, current management targets exclusively the development of very old forests. The problem is that because habitats and population are not monitored in a coordinated manner, we do not know if the non-linear relation between the quantity of old forests and owl populations is valid for all the monitored zones or if it is a strong relation. And the result is the spotted owl continues to decline without any clear idea of the cause.

Romain Julliard. Our own habitat descriptions exist, thankfully, but are managed by observers with a possible observer effect. However, a recent partnership with Teruti (annual land-use survey by the Agriculture ministry) made it possible to produce several scientific publications because the Teruti data provide truly novel data-analysis possibilities for changes in land use. We also often use the Corine Land Cover and the data from the Paris-region land-use MOS atlas to describe the habitats around each observation point and analyse the relations between these parameters and the biodiversity data. But this type of project works only if both partners really want to work together. There has to be real collaboration, which requires time and effort to align the two databases, extract the useful data, use the unprocessed data to calculate the most relevant variables for analysis and for which the best recommendations can be made by the experts of each database.

What are the links and the differences between citizen monitoring and SINP (information system on nature and landscapes)?

Romain Julliard. The goal of SINP is above all to list and clarify the inventory data, presenting the metadata (description, size of data region/plot, data precision, accessibility, contact person), whereas Vigie-Nature is a system of structured data in view of analysis for monitoring purposes or to assess the effects of a practices gradient on the diversity of a given taxonomic group. Even though SINP comprises both monitoring and inventory data, efforts are made primarily on the inventory data, for which descriptions are lacking, whereas there are no problems for the monitoring data.

Marion Gosselin. Is the end goal to analyse all the listed and aligned data?

Romain Julliard. Theoretically, yes. But it is doubtful that scientists will be willing to analyse data if they were not involved in collecting or listing it.

Frédéric Gosselin. Why? Our teams at Cemagref use part of the IFN data without too many problems.

Romain Julliard. Those data are very standardised and, in fact, quite simple. For example, Onema (National agency for water and aquatic environments) has difficulties publishing its data on electric fishing even though the data are standardised and of better quality than the STOC data. They go to great efforts to build and maintain the

database, yet, in comparison, they lack funding to find people to analyse the data. The strength of Vigie-Nature is its active database that our scientists know very well and that can be used to publish new results each year. We waste no time finding a database, becoming familiar with it. And after analysis and publication of the results, we are not obliged to start over with a new, external database. The presence of a permanent analysis team and the very strong partnership with the data producers ensures great efficiency in data analysis and publication of the results.

Marion Gosselin. That partnership is probably missing in SINP, which simply lists, for information documents, the inventories and monitoring projects that exist, but that all have different protocols. That is useful as a catalogue of metadata, in the same way that the catalogue of metadata on forest information sources (Ca-SIF), developed by the Ecofor professional group (GIP Ecofor), is useful. But even if SINP did provide direct access to the data, I wonder how the data from different protocols could be combined and used.

Frédéric Gosselin. It may be possible, but not without a permanent team to analyse the data. In addition, it would be worthwhile to put some thought into data quality. For example, why list databases on species presence, if this type of data does not provide information that can be used for statistical processing?

Romain Julliard. It would be a good idea to design a system where research is an integral part of data collection.

The Research ministry and CNRS (National scientific research centre) are thinking about observatories for environmental research. Could they be used to assess public policies for biodiversity conservation?

Frédéric Gosselin. It would be unwise to let people think that these observatories on research could be used as operational monitoring observatories, whose results would serve to make decisions on management or policies (e.g. forestry or agriculture). In my opinion, the link between the two is far from automatic and merits ample, prior study. I do not agree that the changes in biodiversity observed on LTER (Long-term experimental research) monitoring sites, which are designed to study precise biological mechanisms, can be used to assess the effects of public biodiversity policies.

Romain Julliard. We need other levels than the LTER sites. The current approach is too focussed on opposing the various systems (remote sensing, inventories, LTER sites) whereas we must enhance compatibility between them.

Frédéric Gosselin. For the National observatory for biodiversity project, the Ecology ministry is attempting precisely to improve compatibility between the existing systems and that is a good thing. However, data on certain sectors is lacking and monitoring systems must be created

for those sectors. It is not enough simply to establish a network for what already exists. For example, we lack data to evaluate the role of forests in biodiversity because, for instance, citizen monitoring of bats is not suited to forest bats. We have data on forest flora, but that group is not the most original part of forests nor the most threatened. On the other hand, we have almost nothing on deadwood organisms, mushrooms, Coleoptera and mosses, which contribute to the richness and originality of biodiversity in forests and are, in some cases, threatened.

In conclusion...

Marion Gosselin. I draw a frustrating conclusion from this discussion. I am aware that we cannot monitor everything for biodiversity. But I am sorry to see that current monitoring is guided by purely pragmatic criteria (we monitor only those taxa for which volunteers are willing to provide inexpensive and abundant data) and that there is no political will to invest in the important taxa given the current context of biodiversity erosion, i.e. taxa that are not necessarily notable or noticed, but are nonetheless threatened.

Frédéric Gosselin. Another impression drawn from this discussion is that of spheres (political, scientific, the associations) that are too disjoint in the field of biodiversity, whereas they work together well in other fields.

Romain Julliard. In North America, for example, with the adaptive-management movement, management and research are much more integrated in the field of conservation biology. But that did not occur overnight, it took 20 years to reach that result. We cannot improvise with adaptive management in France because we do not have that culture of joint scientific work. The pragmatic solution that might be suitable for the European context is more in the style of evidence-based conservation, that the English are developing by trying to group the management services to gain knowledge and not lose the information drawn from management experiences. That corresponds better to our work habits, but must still be set up, taking into account the fact that the conservation-biology community in France is very small. ■

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