

INRAE

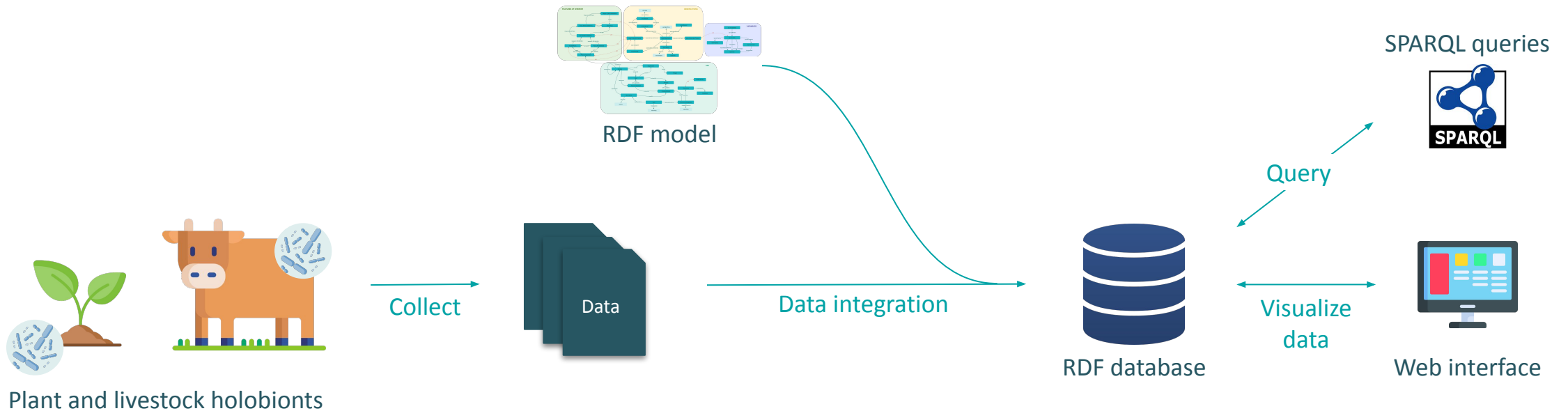
➤ **Holograph - A schema to describe holobionts in agroecology**

PEPI IBIS days - 15 octobre 2025 - Marie Lahaye

MUDIS4LS-IS5

Mutualised Digital Space for FAIR Data in Life and Health Science

Goal: Provide an operational framework to facilitate the collection, storage, querying, analysis and accessibility of holobionts data and metadata



DEEP IMPACT project

Usecase - Plant holobionts

Goal: understand the impact of microbial diversity on the soil, as well as physico-chemical and environmental conditions on health and yield of wheat and rapeseed crops

Types of data collected or generated:

- **Climatic data**
- **Agro-environmental descriptors** on fields, plots and plants (bioagressors inventories, plant phenotypic traits, agricultural practices, ...)
- **Metagenomics data** - ASV abundance and taxonomic assignation to study microbial diversity in leaves, roots, rhizosphere and bulk soil

A **model** was being developed to describe these data



DeepImpact project

Example of questions this model wanted to answer:

1. Which **taxa** are found in **root microbiota** of **fields** located in **western** France under **conventional agriculture** in the **2nd sampling** of the **2nd year** ?
2. Which **taxa** are found in the **bulk soil** of **plots** located in **eastern** France where the **weed CHEAL** at the **phenological stage D** is present



Holograph

A schema to describe holobionts in agroecology



Plant holobionts modelization as a RDF graph - finalization and generalization of the DEEP IMPACT model

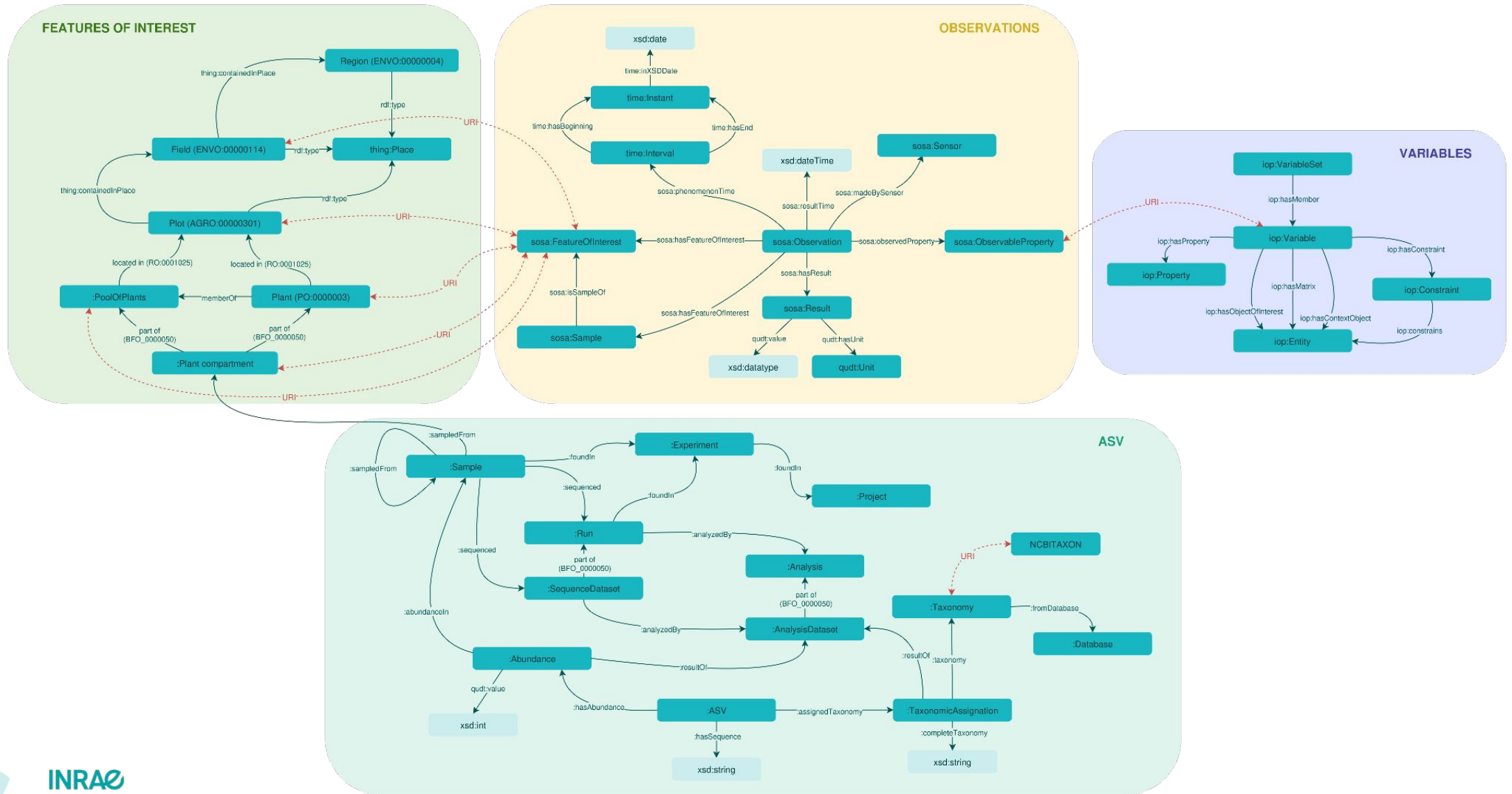
Why RDF ?

- Use of ontologies. *Ex: SOSA, I-ADOPT, ENVO, AGRO, ...*
- More flexible model
- Reuse existing resources and interrogate them with federated requests. *Ex: NCBITAXON*

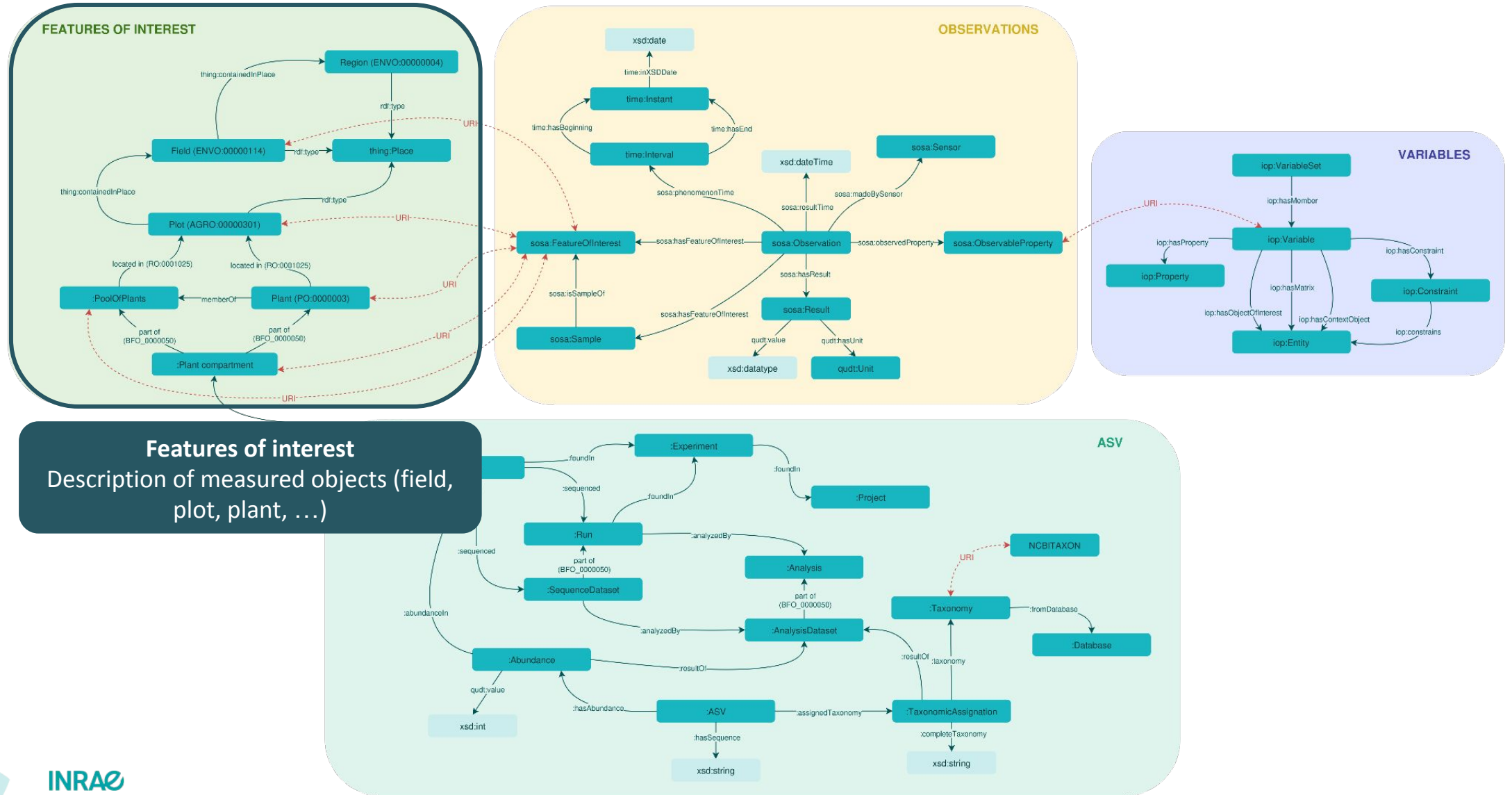
Using the DEEP IMPACT project as a usecase to test the model



Complete model



Complete model



Features of interest
Description of measured objects (field, plot, plant, ...)



INRAE

Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye

Features of interest

Field

Field (ENVO:00000114)

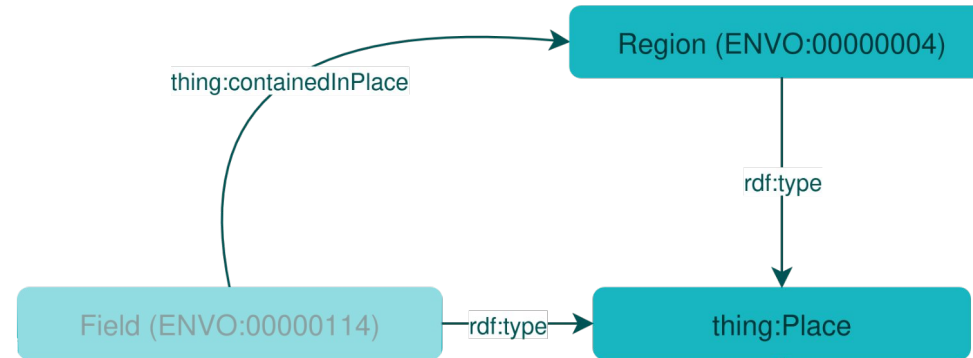


INRAE

Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye

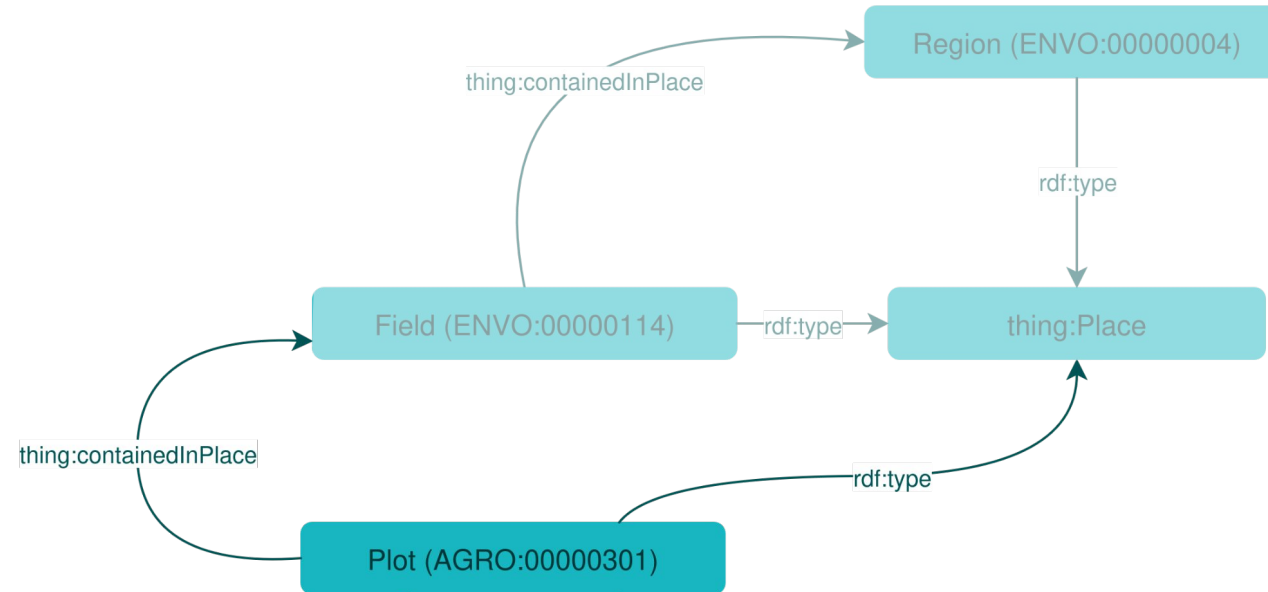
Features of interest

Region



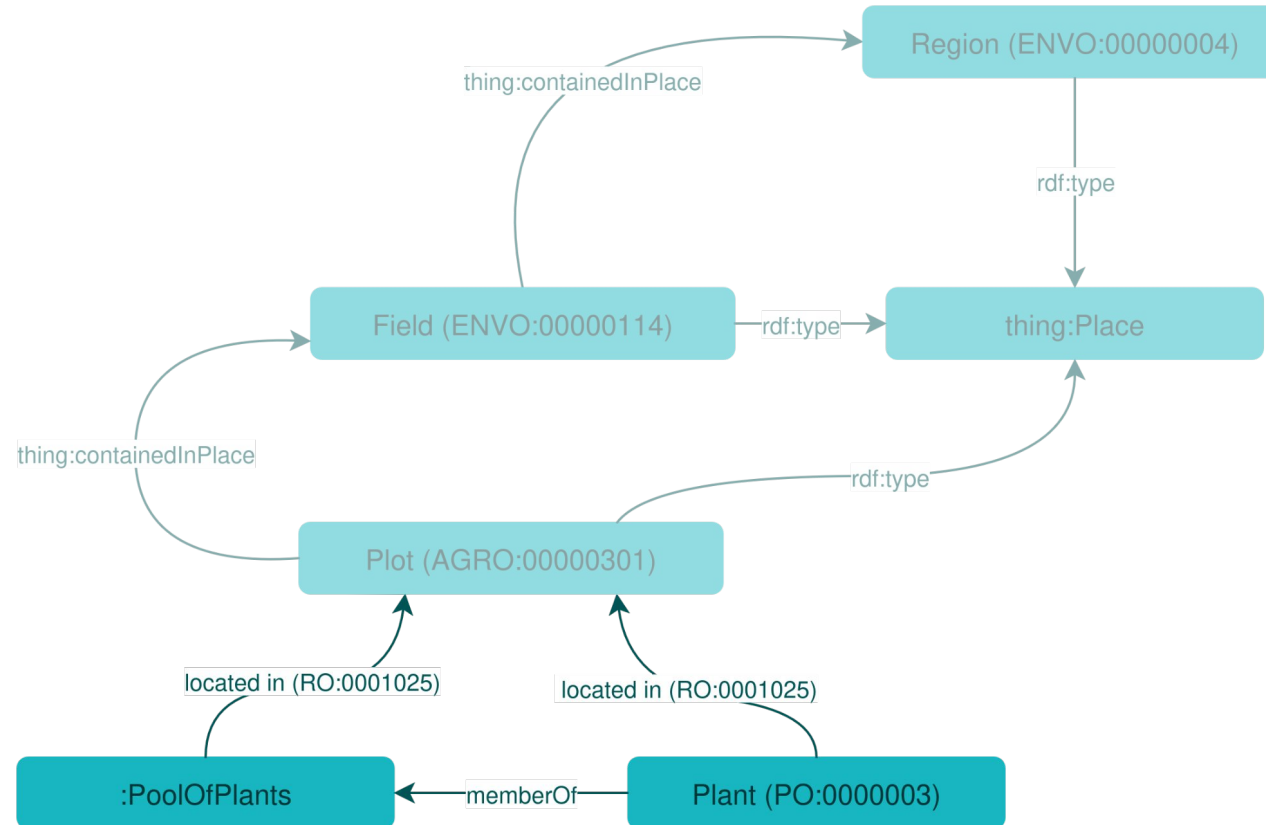
Features of interest

Plot



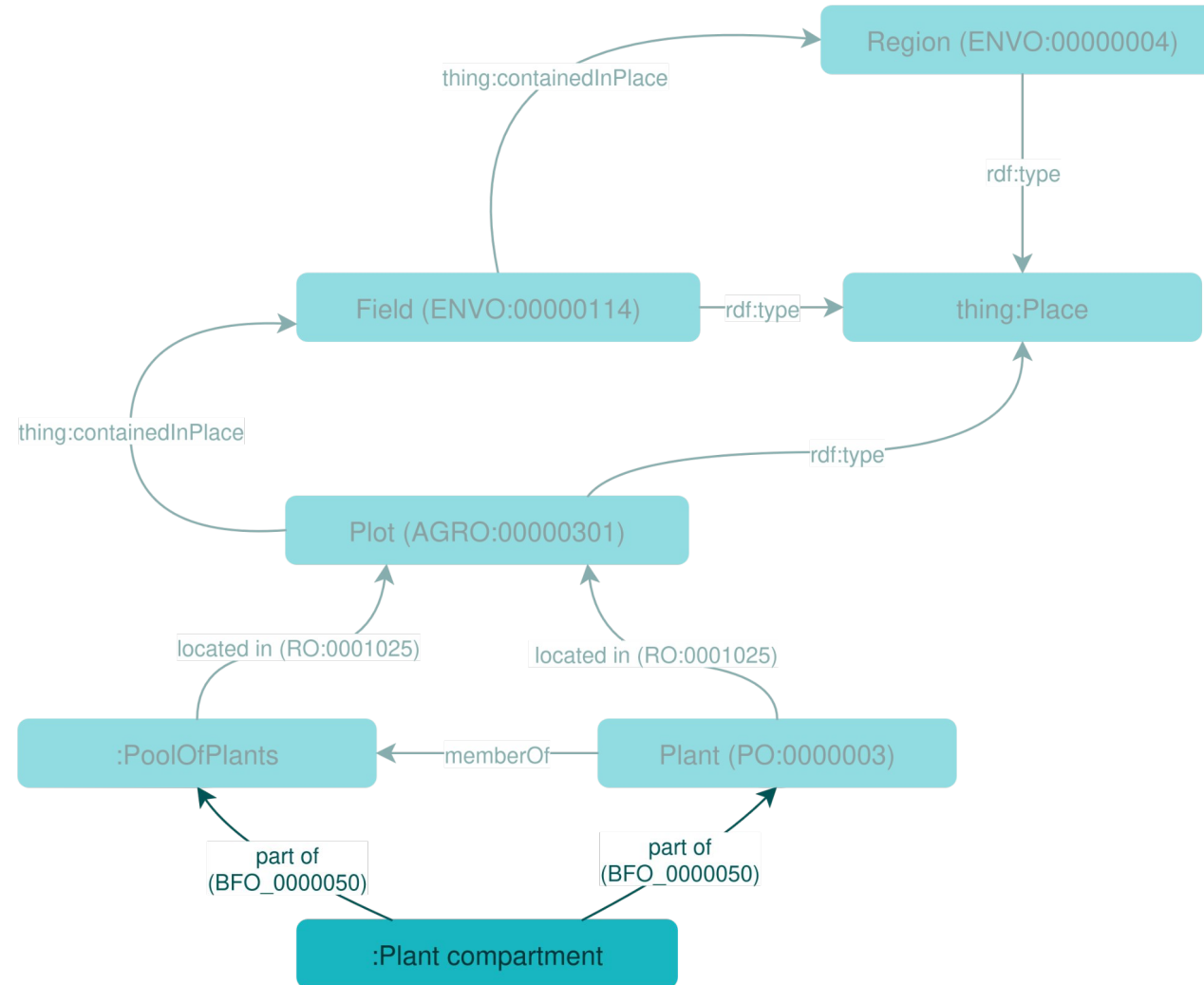
Features of interest

Plant and pool of plants

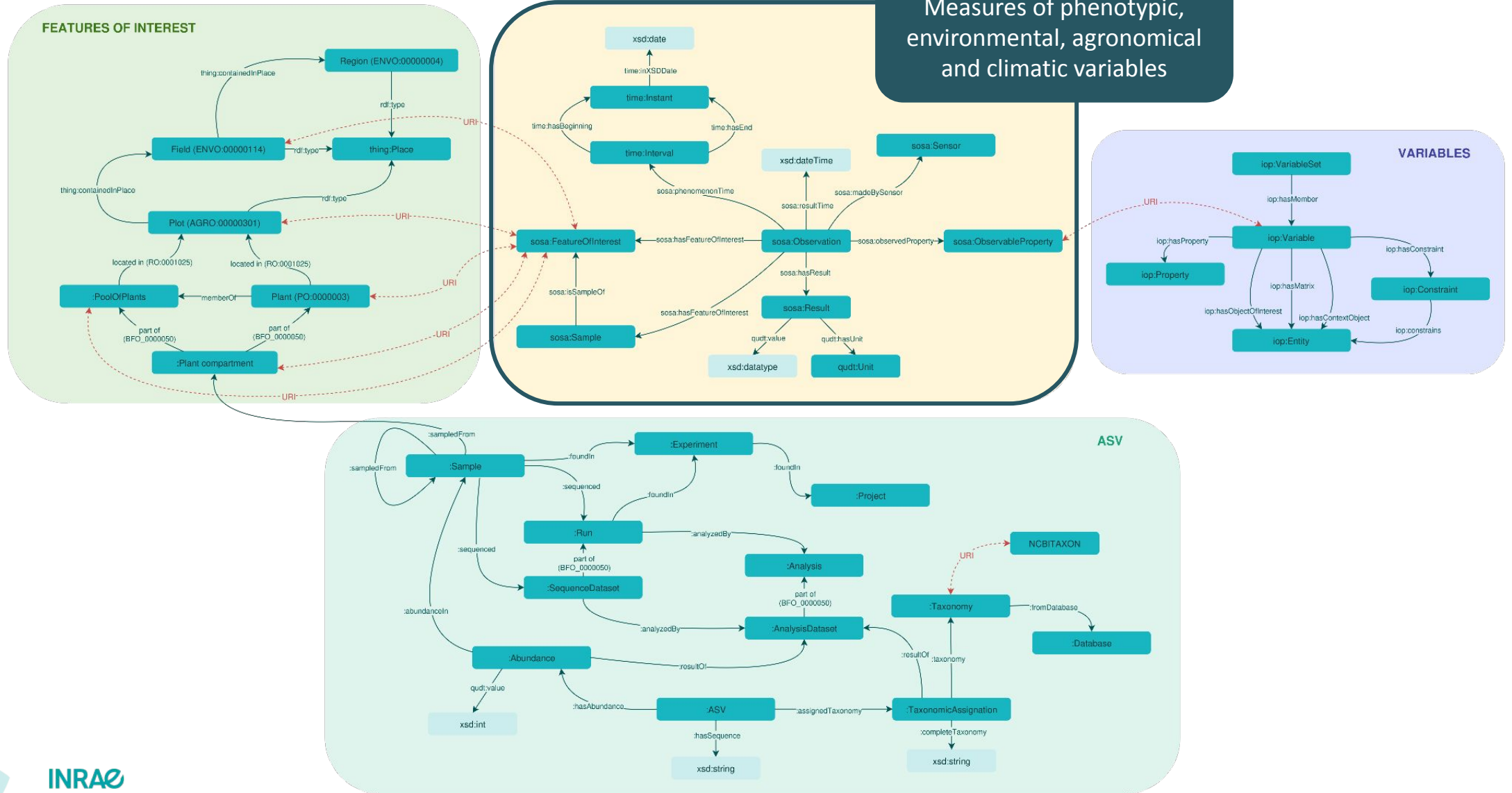


Features of interest

Plant compartment - roots, leaves, rhizosphere, ...



Complete model



SOSA/SSN ontology (Semantic Sensor Network Ontology)

Observation - Measurement of a property of an object

sosa:Observation



INRAE

Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye

SOSA/SSN ontology (Semantic Sensor Network Ontology)

FeatureOfInterest - Object on which a measurement is done

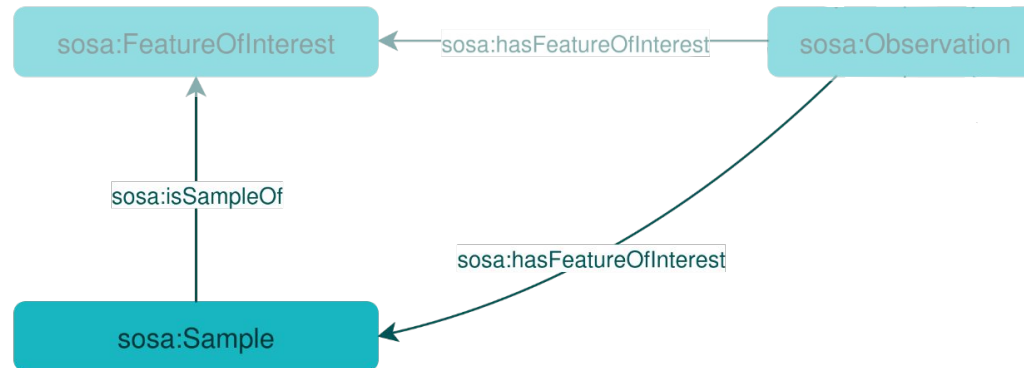
Types of features of interest:

- Field
- Plot
- Plant
- Plant compartment



SOSA/SSN ontology (Semantic Sensor Network Ontology)

Sample - Subset or extract from a feature of interest on which a measurement is done



SOSA/SSN ontology (Semantic Sensor Network Ontology)

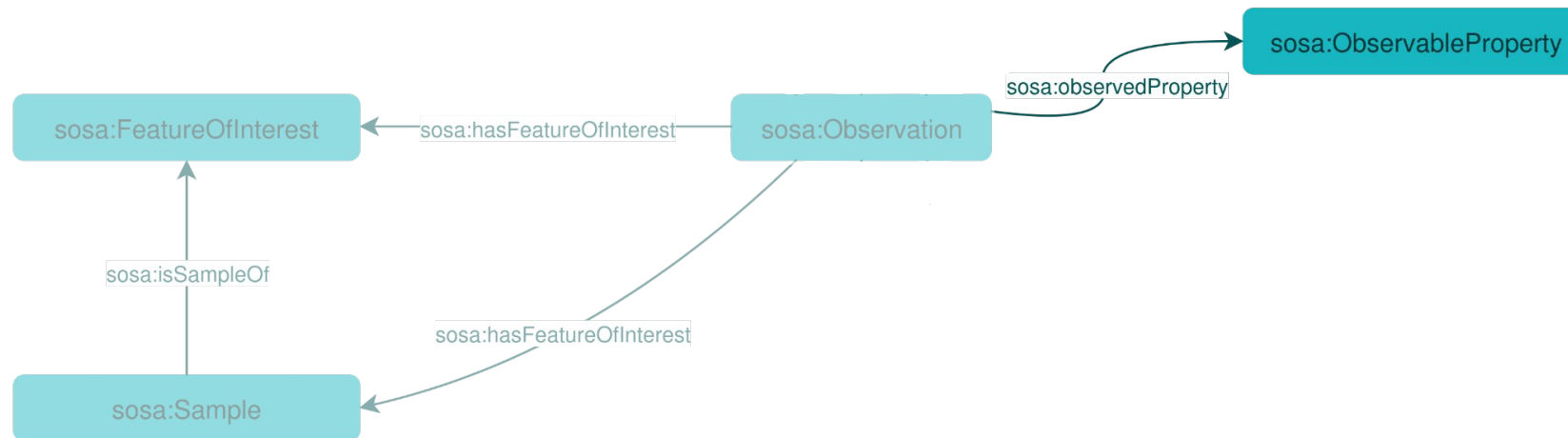
ObservableProperty - Measured variable

Simple ...

- Soil data: magnesium, calcium, ...
- Biomass data: crop density
- ...

... or complex variables

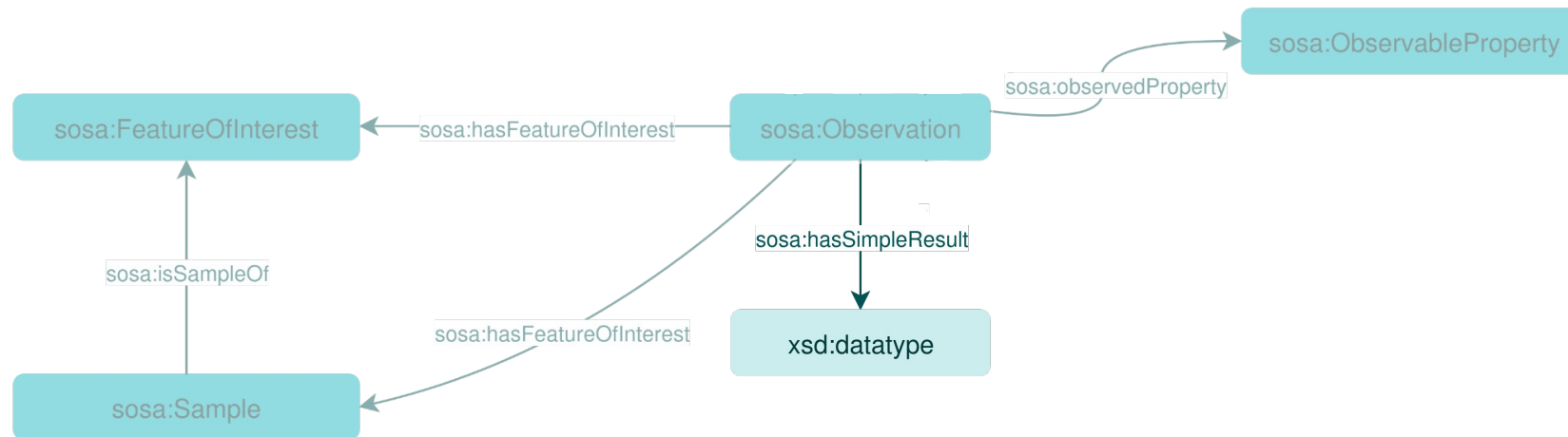
Density class of weed species 3GRAC
at phenological stage A



SOSA/SSN ontology (Semantic Sensor Network Ontology)

Result - Measurement value and unit

Data without unit : Observation linked to a simple value

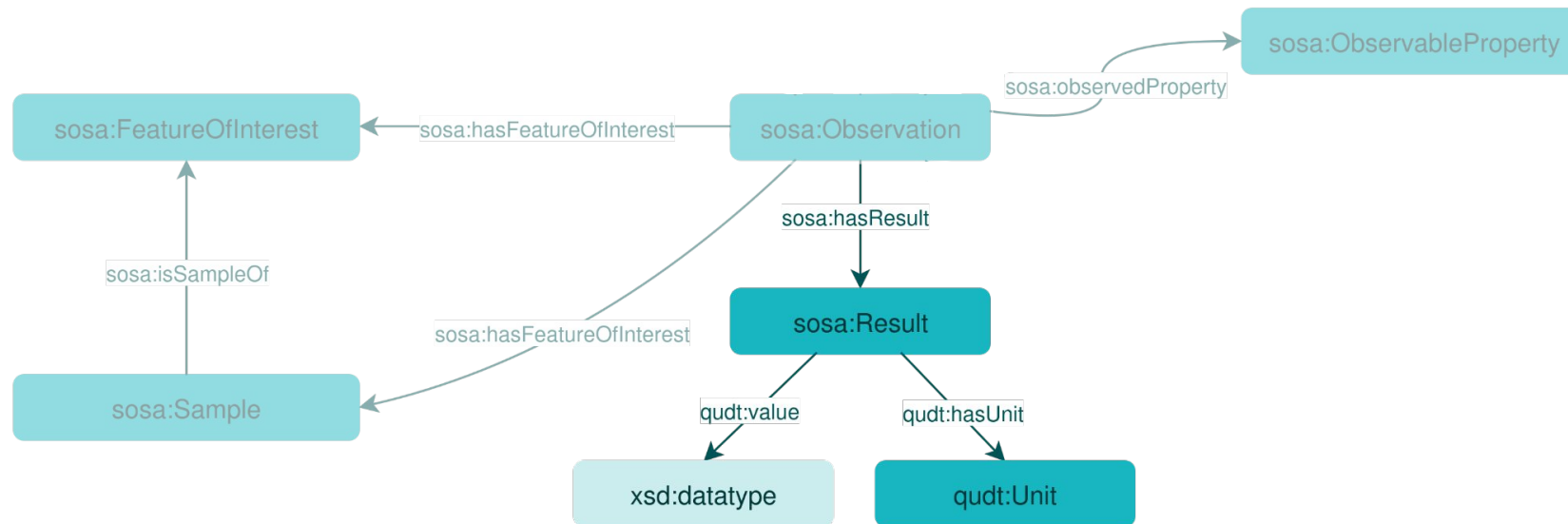


SOSA/SSN ontology (Semantic Sensor Network Ontology)

Result - Measurement value and unit

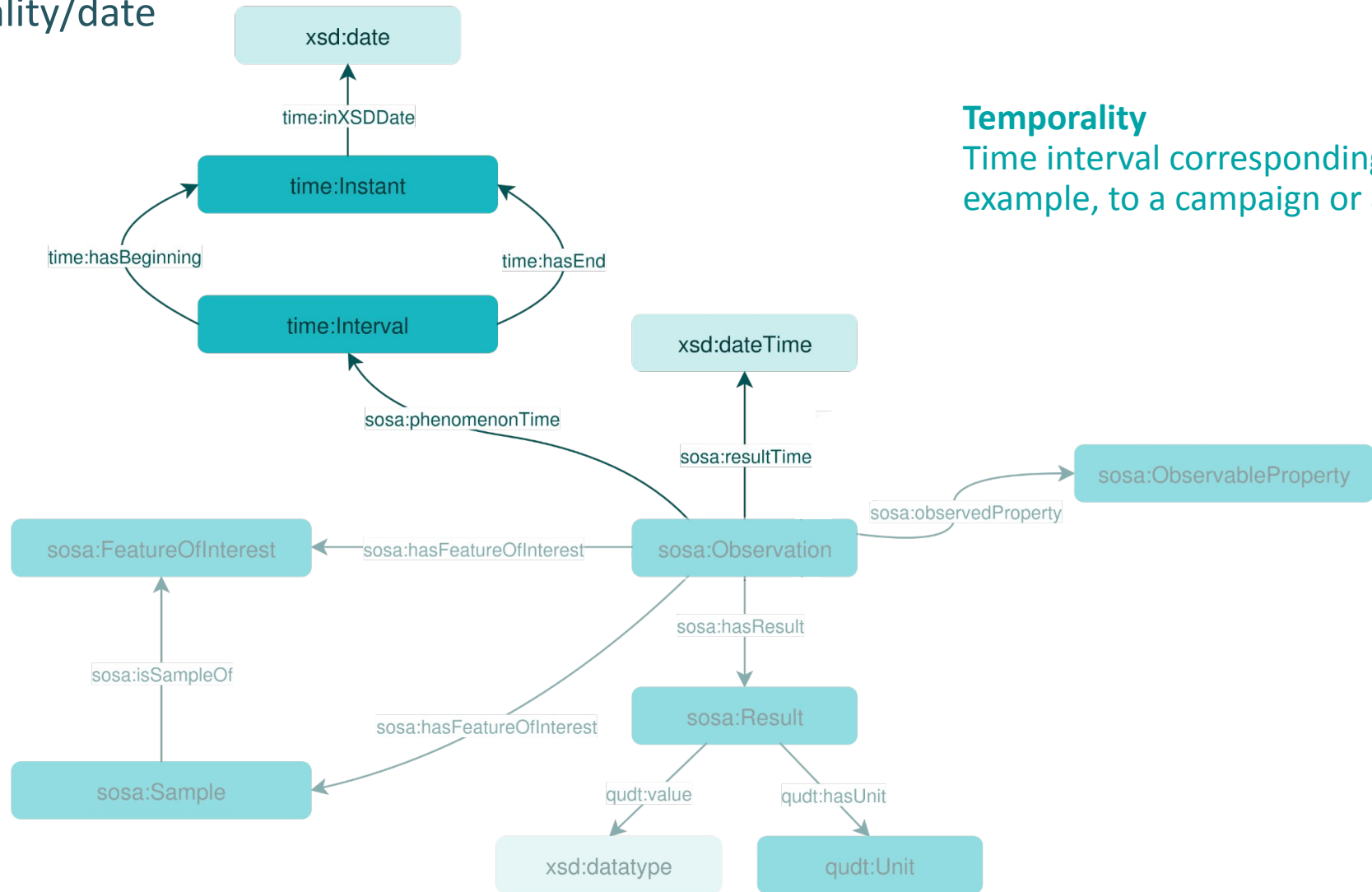
Data without unit : Observation linked to a simple value

Data with unit : Observation linked to a Result which has a value and a unit



SOSA/SSN ontology (Semantic Sensor Network Ontology)

Temporality/date



Temporality

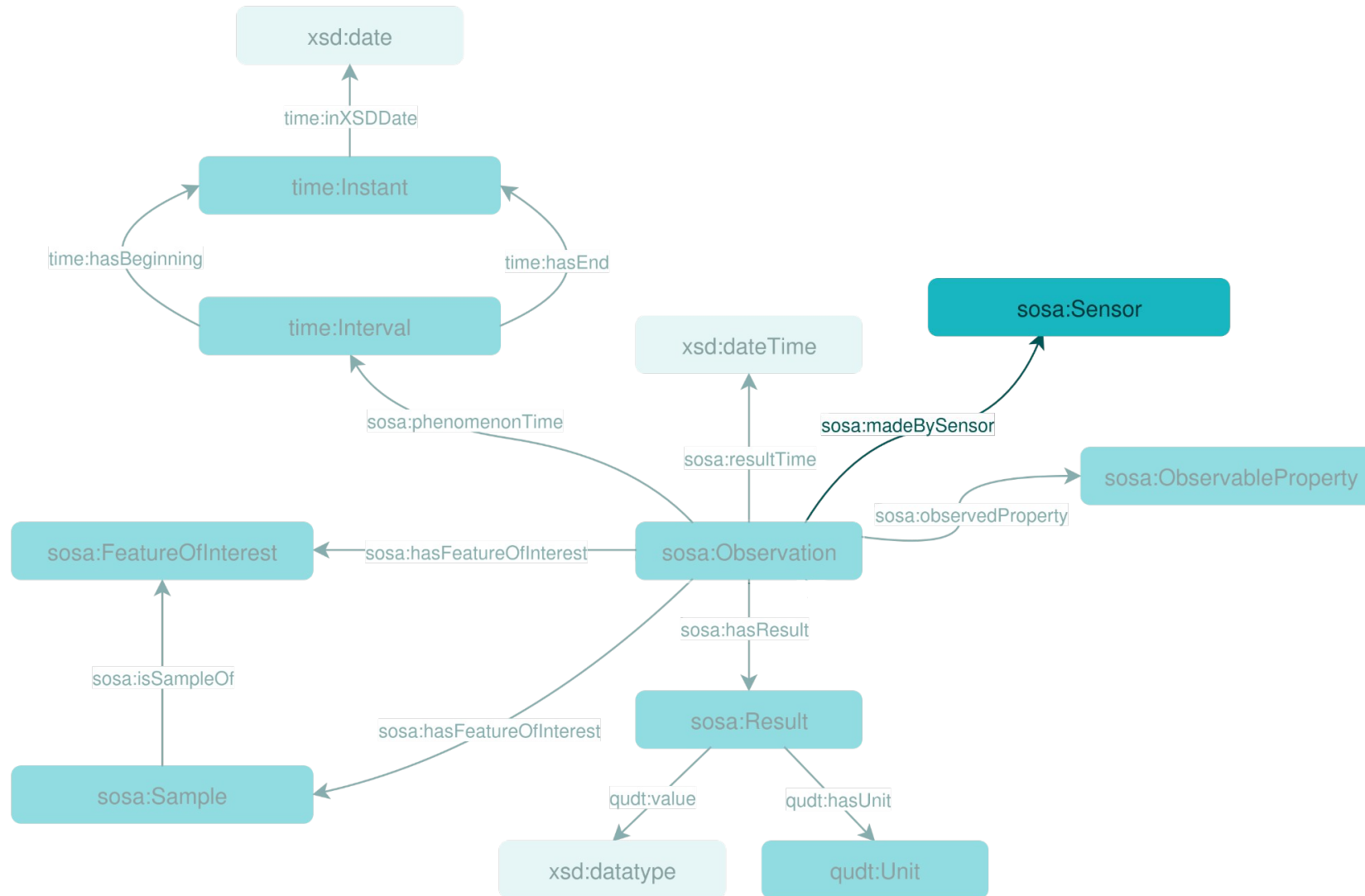
Time interval corresponding, for example, to a campaign or a project



INRAE

SOSA/SSN ontology (Semantic Sensor Network Ontology)

Sensor

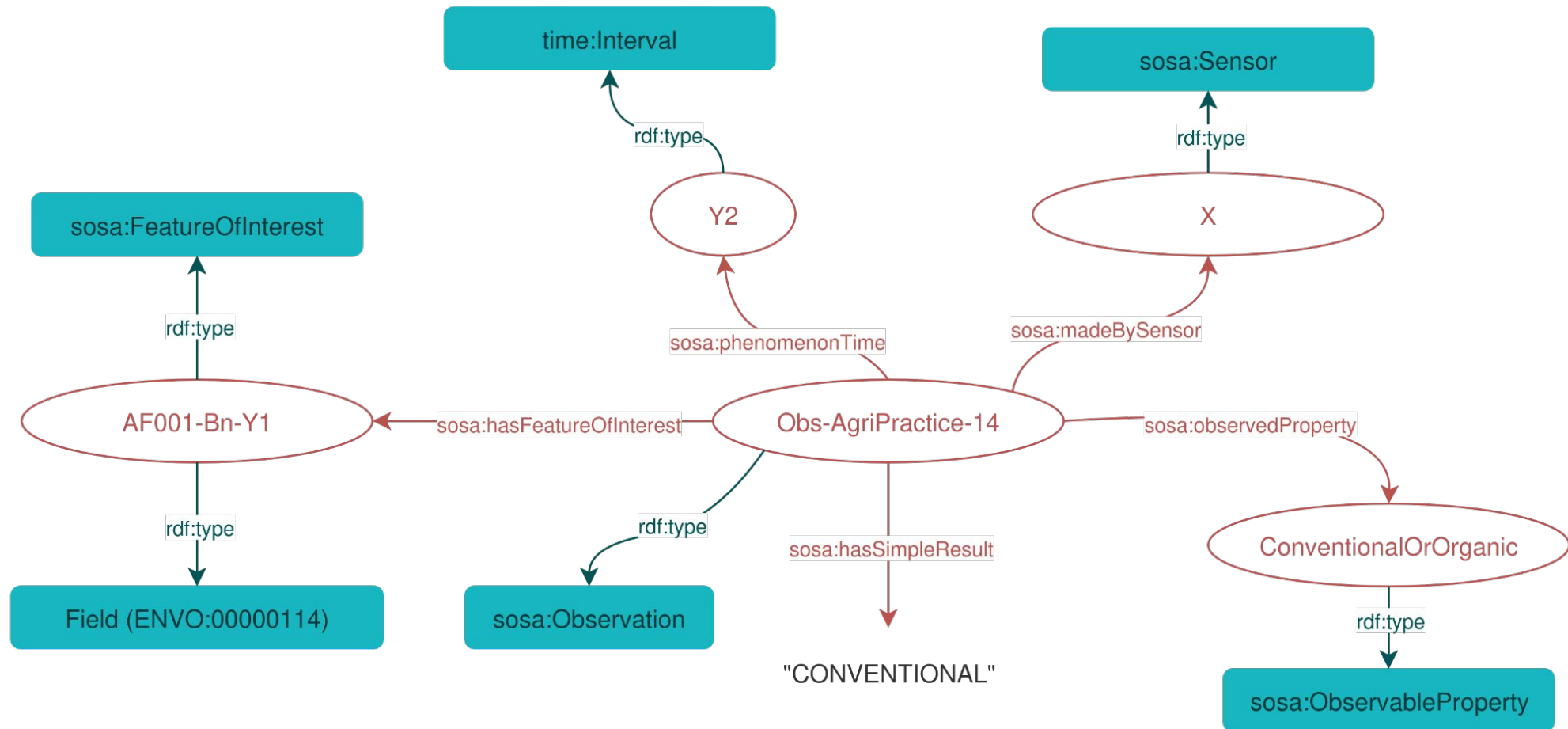


INRAE

Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye

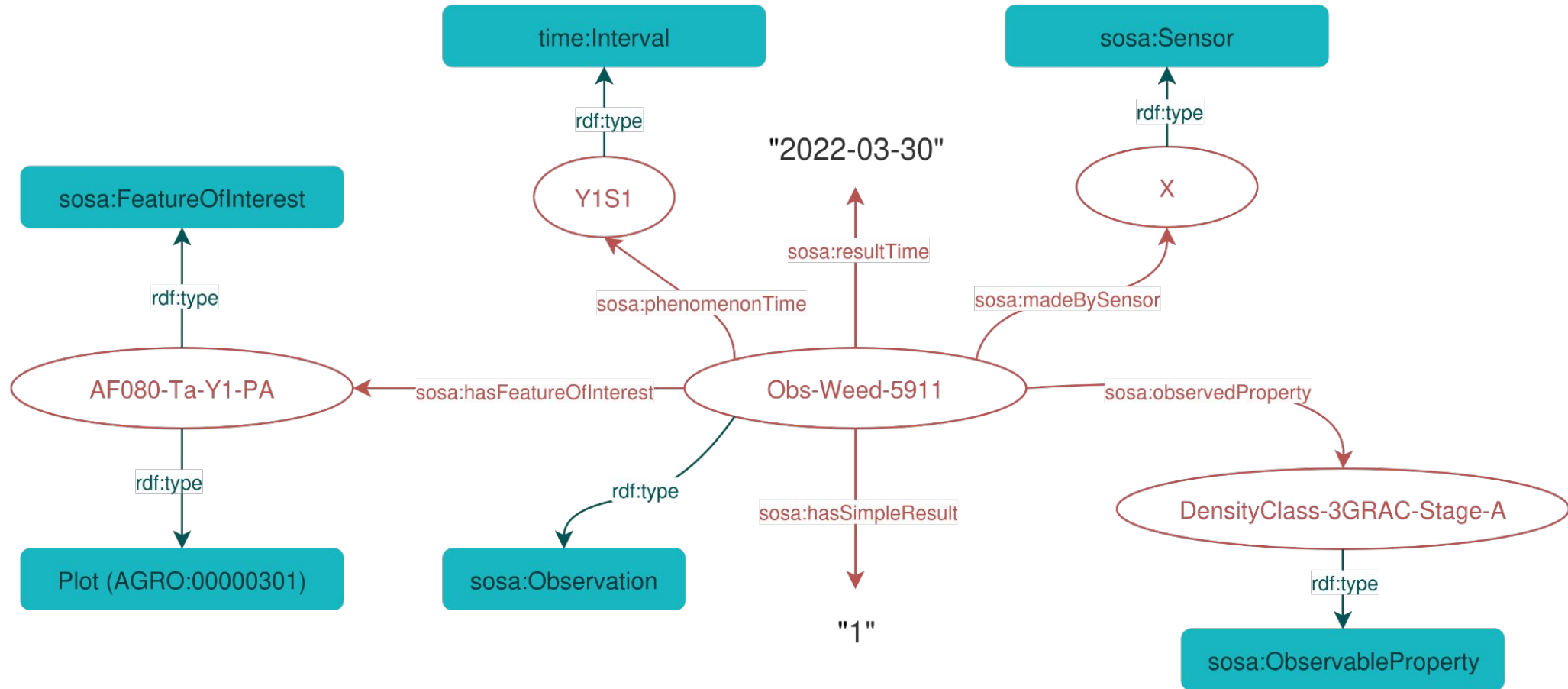
SOSA/SSN ontology (Semantic Sensor Network Ontology)

Example 1 - Agriculture type on the field AF001-Bn-Y1

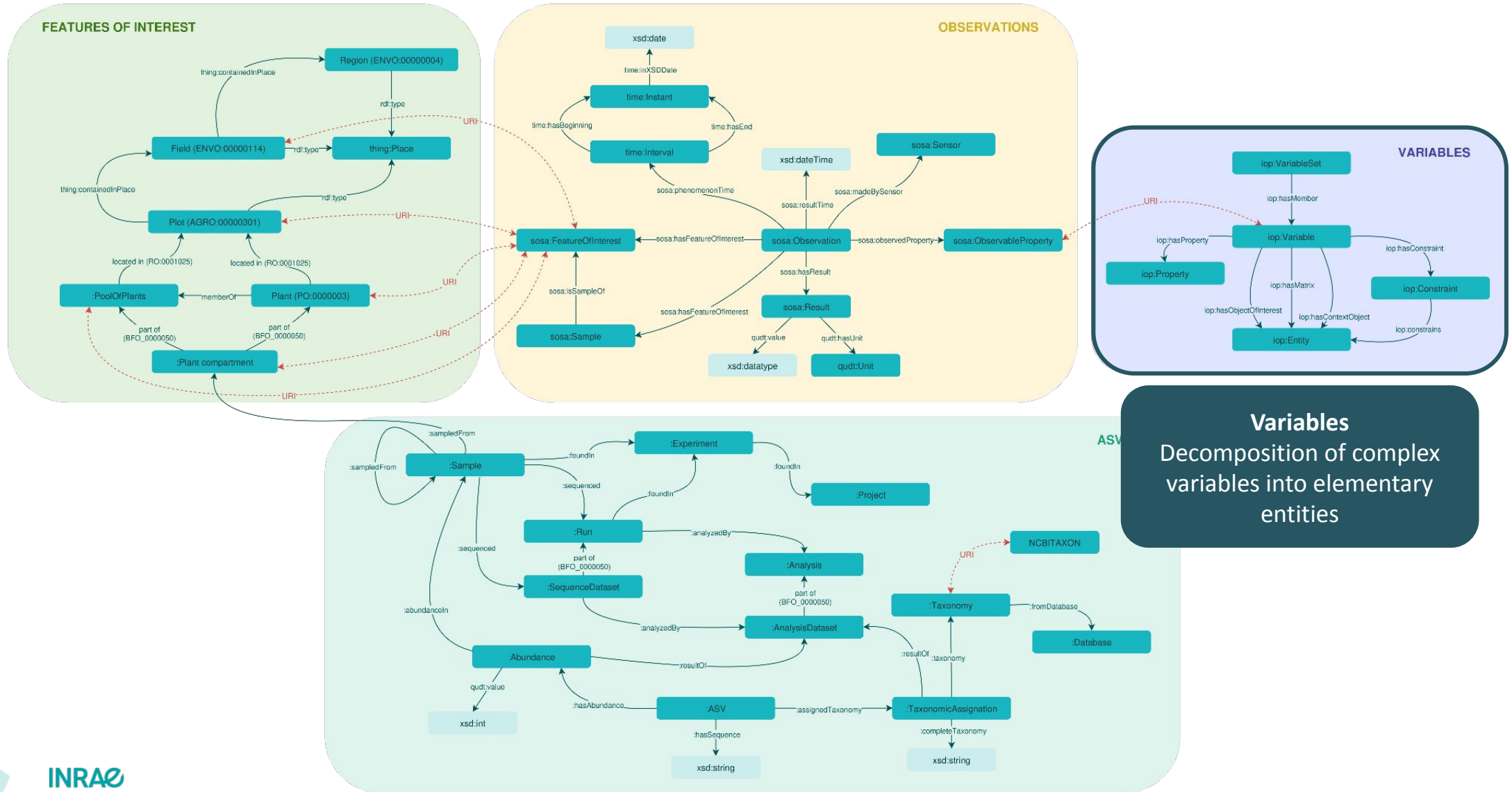


SOSA/SSN ontology (Semantic Sensor Network Ontology)

Example 2 - Density class of weed species 3GRAC at the phenological stage A on the plot AF80-Ta-Y1-PA



Complete model



Variables
Decomposition of complex variables into elementary entities

Variables description - I-ADOPT

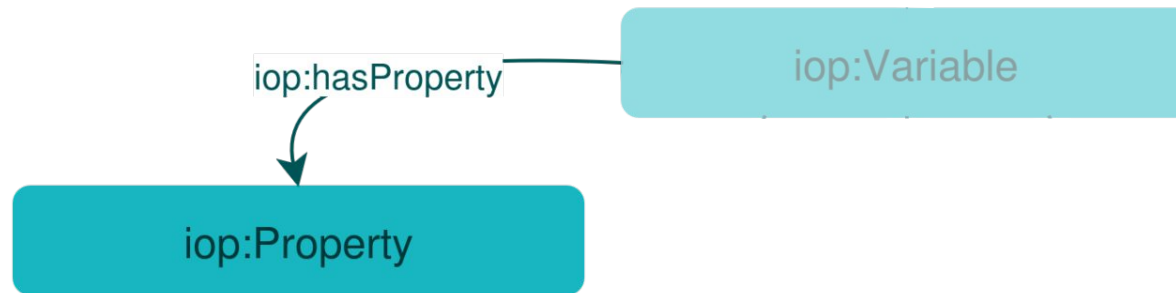
Complete variable

iop:Variable



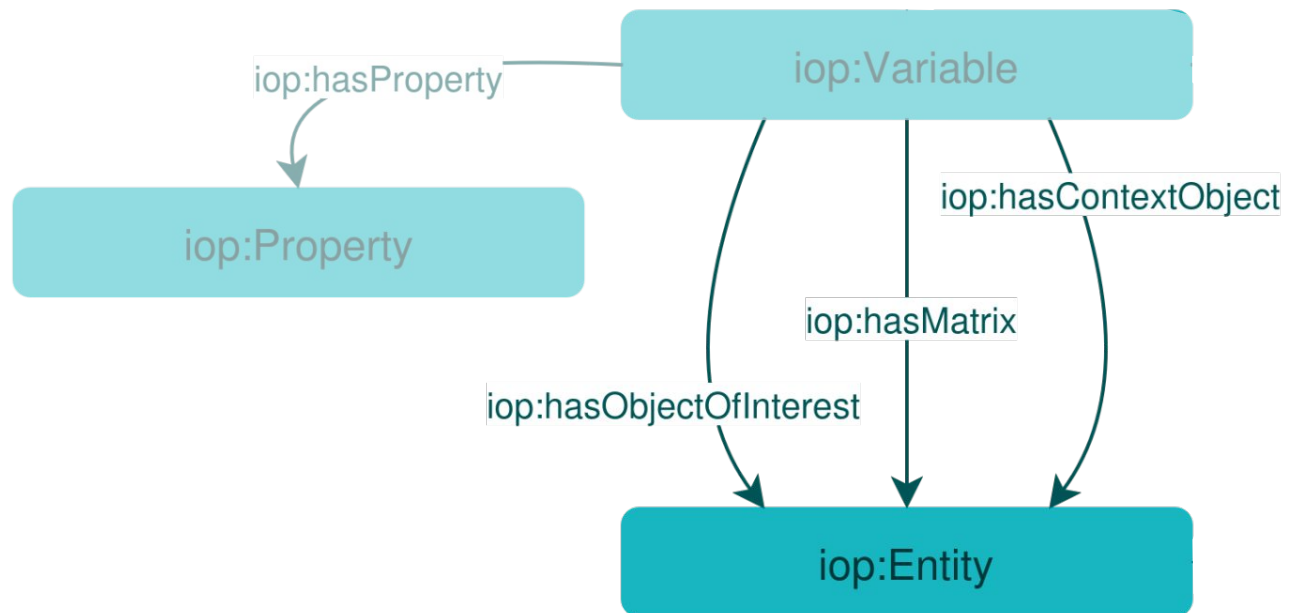
Variables description - I-ADOPT

Measured/observed property



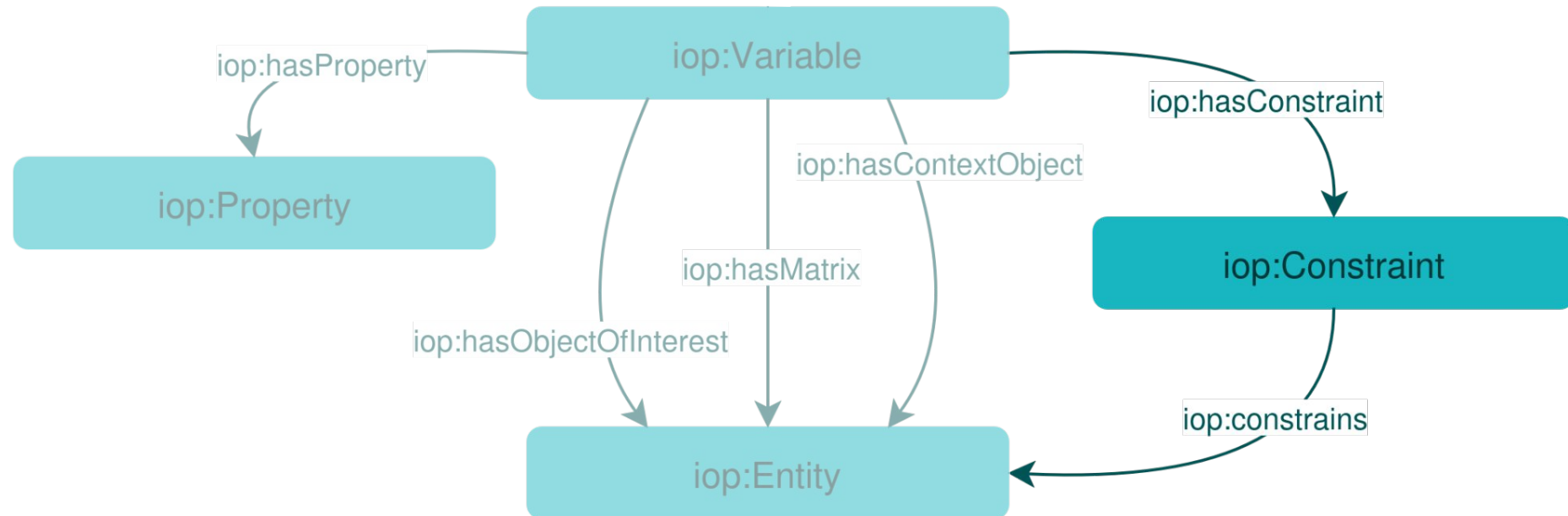
Variables description - I-ADOPT

Entity measured



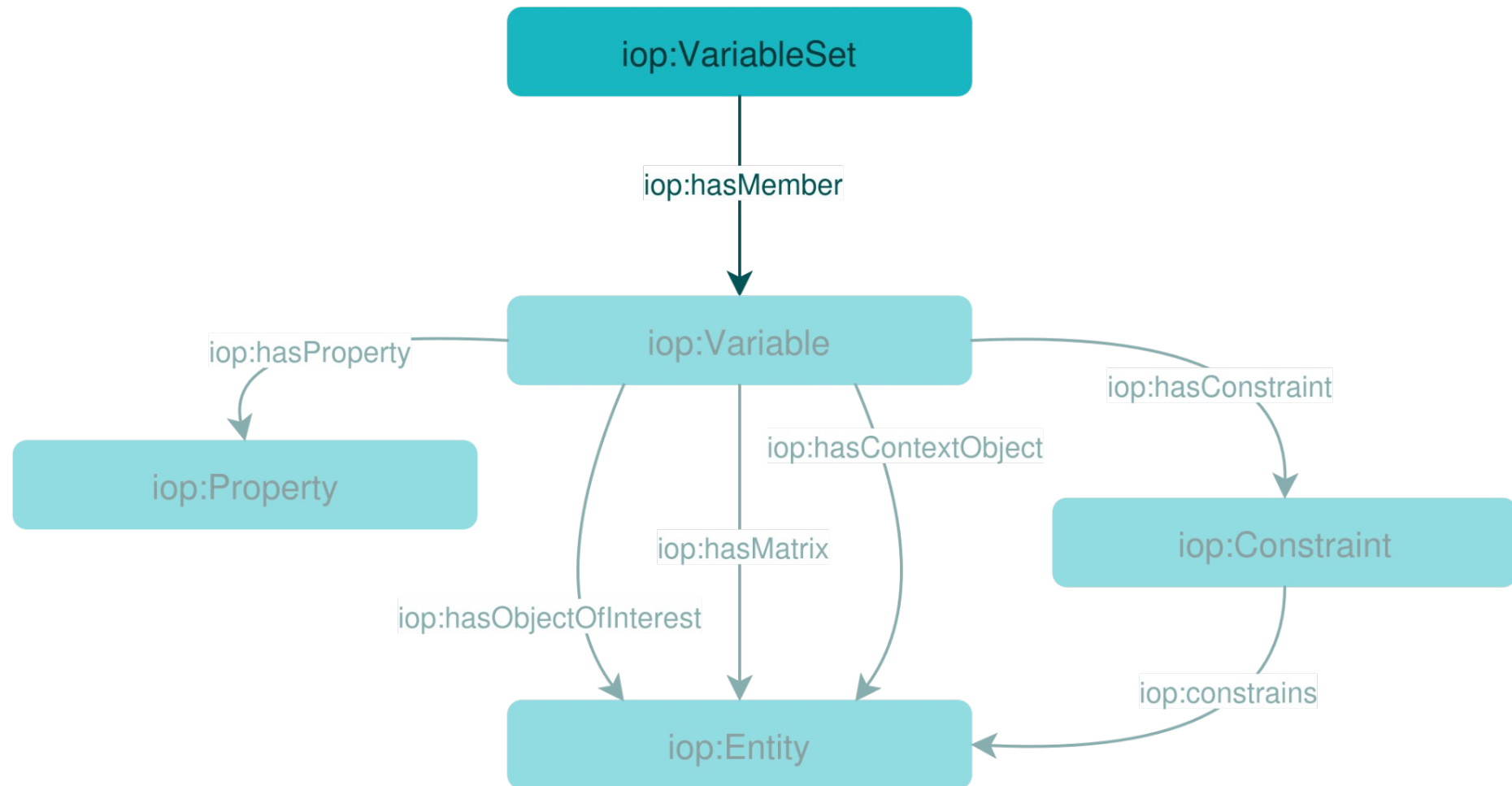
Variables description - I-ADOPT

Constraint



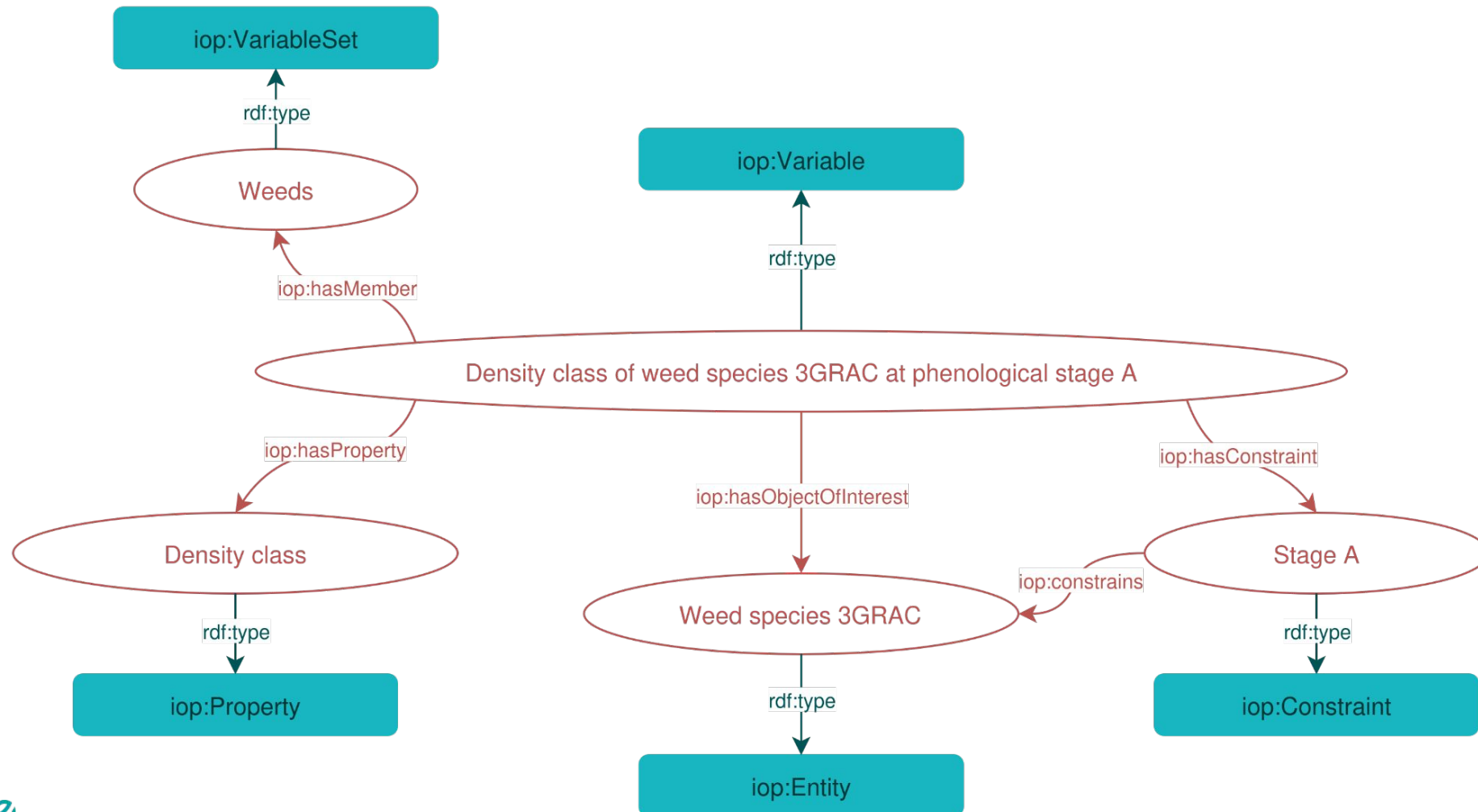
Variables description - I-ADOPT

Variable set

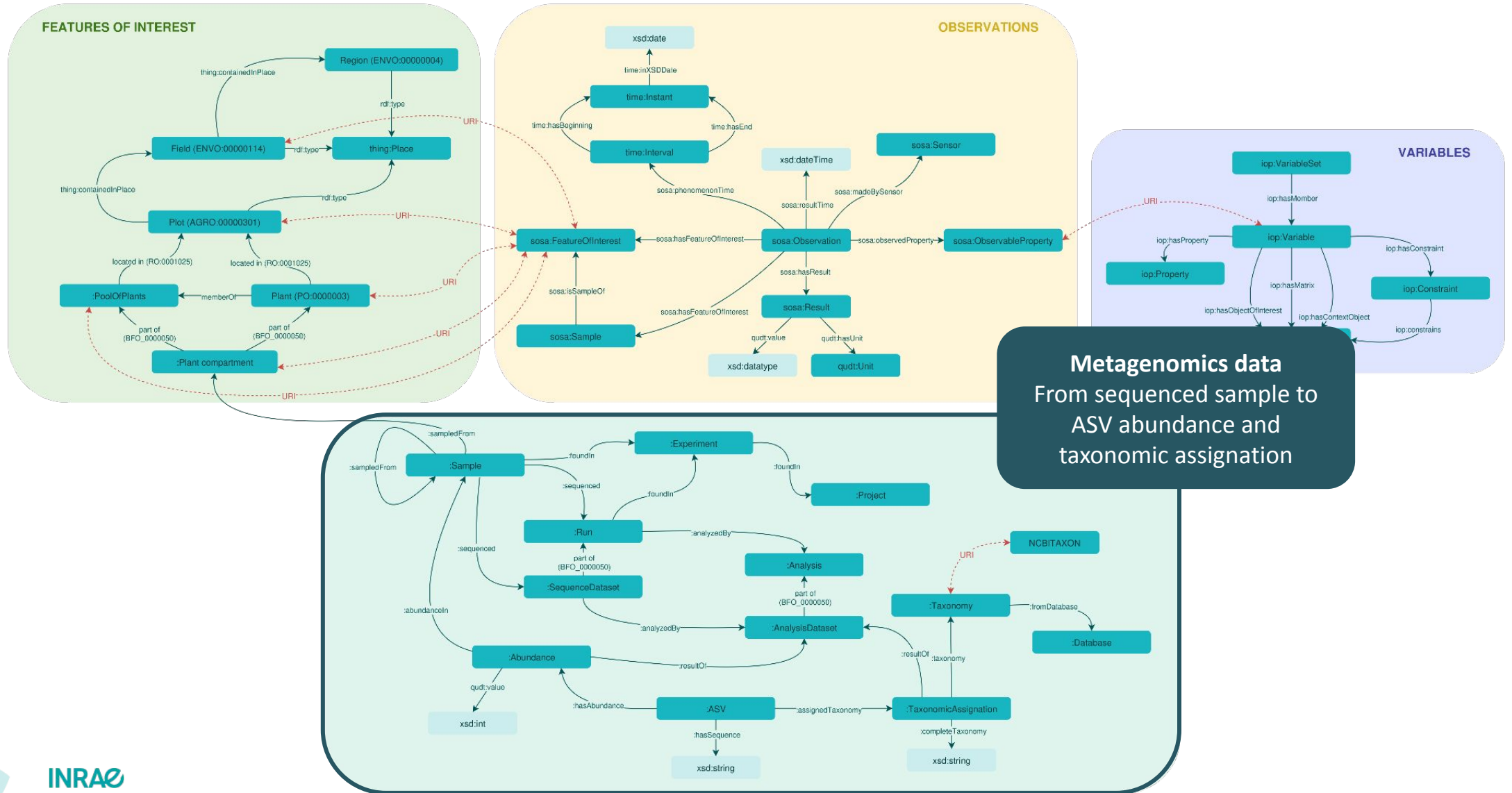


Variables description

Example - Density class of weed species 3GRAC at phenological stage A



Complete model



ASV modelization

Sample

:Sample

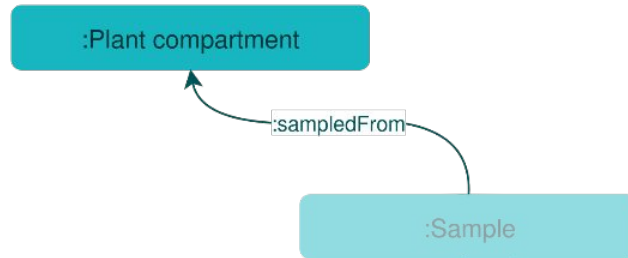


INRAE

Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye

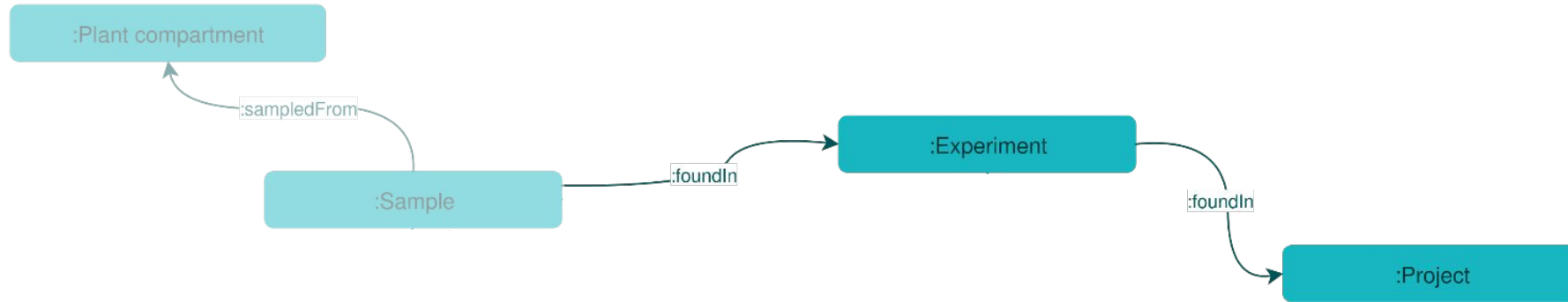
ASV modelization

Plant compartment from which the sample was made



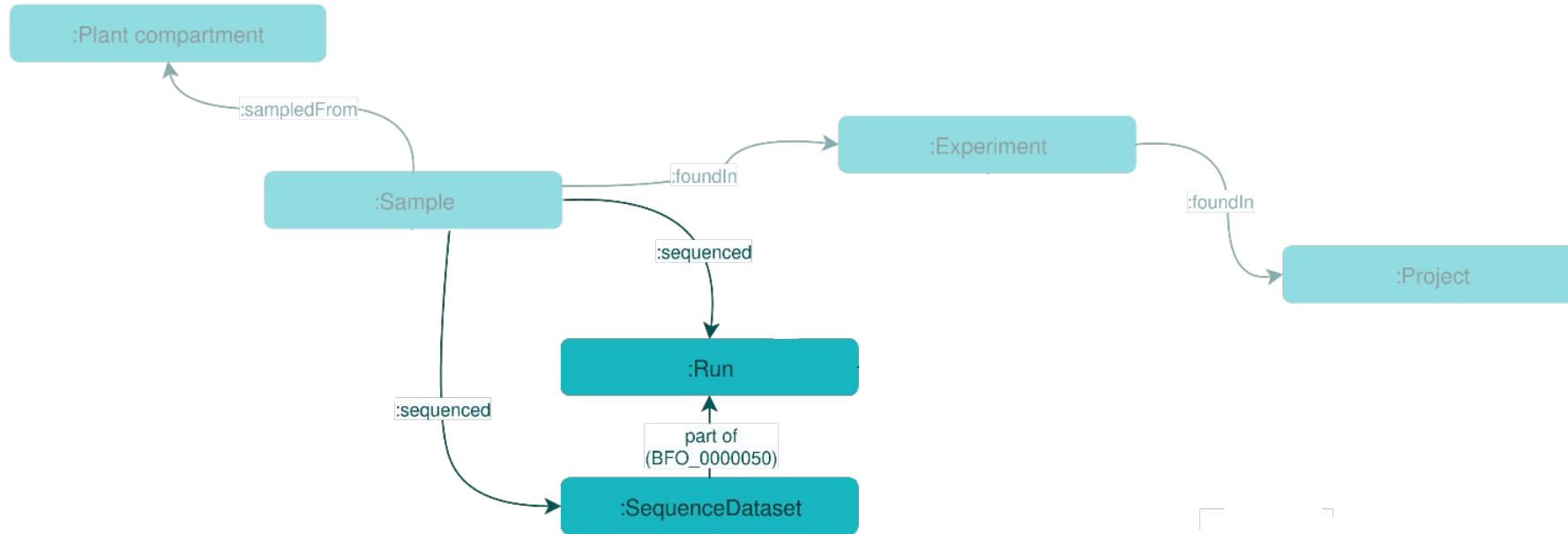
ASV modelization

Experiment and project



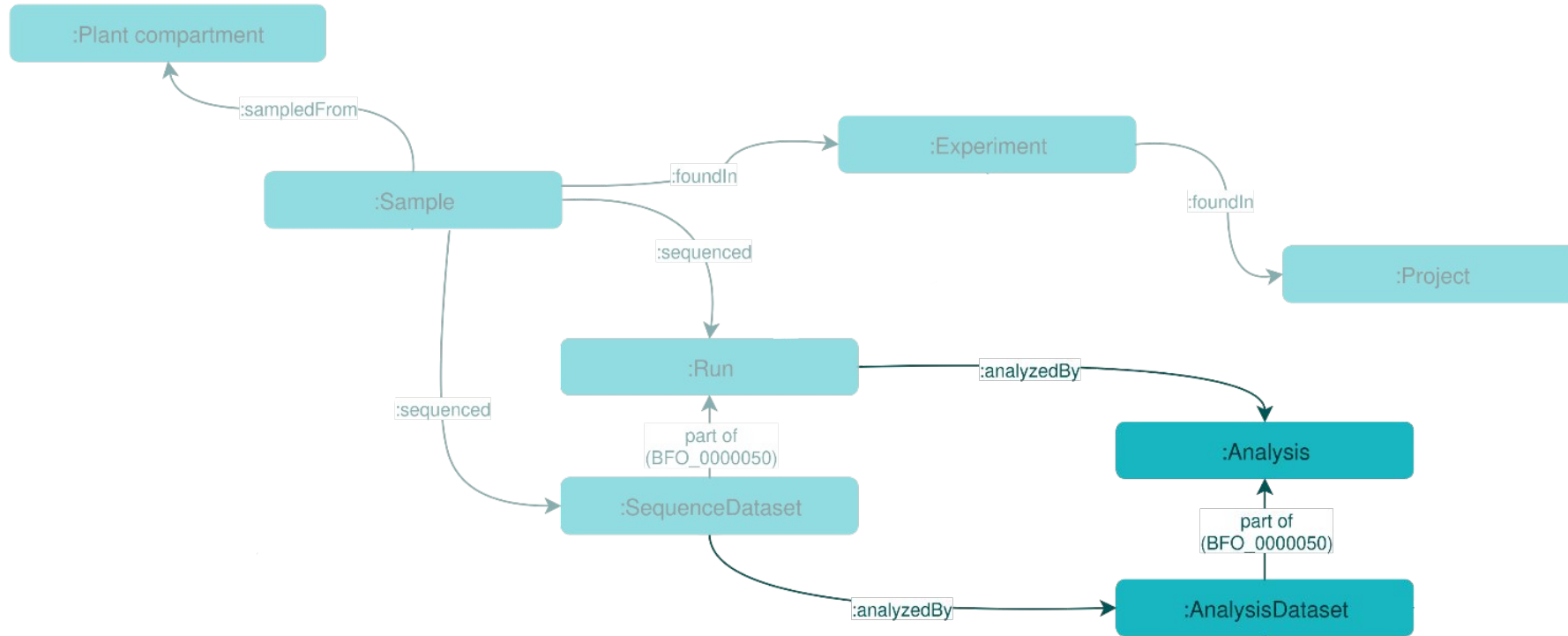
ASV modelization

Sequencing run



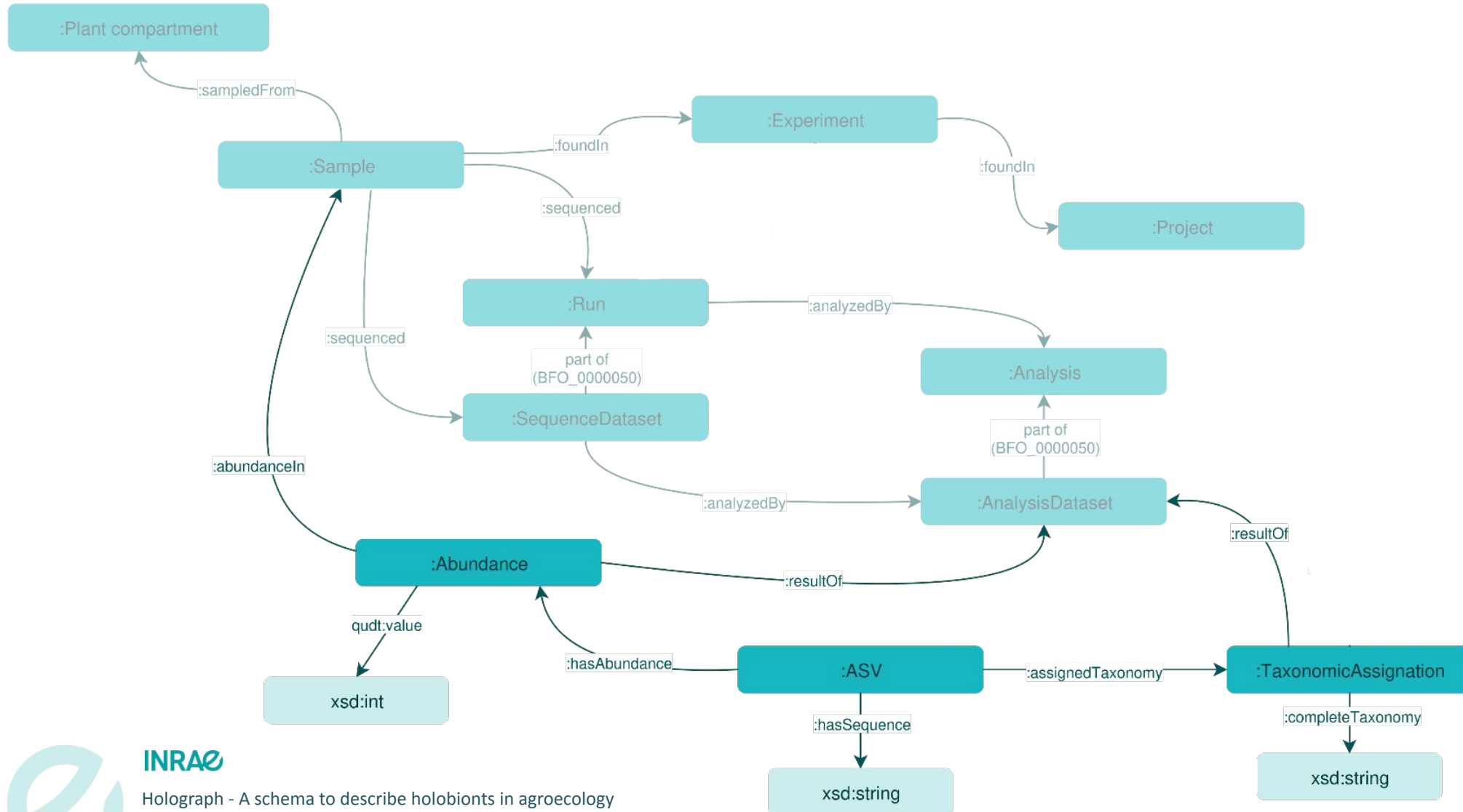
ASV modelization

Analysis



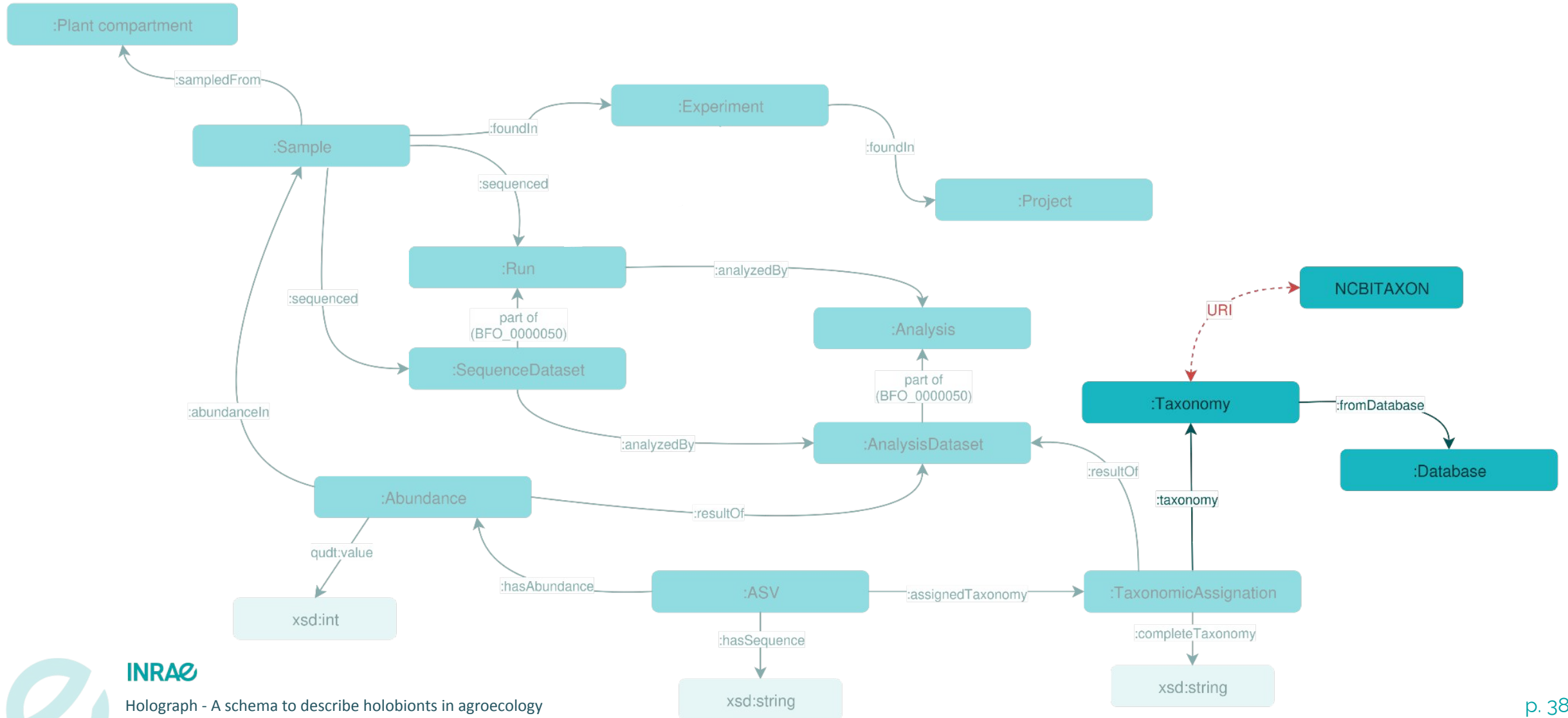
ASV modelization

ASV abundance and taxonomic assignment



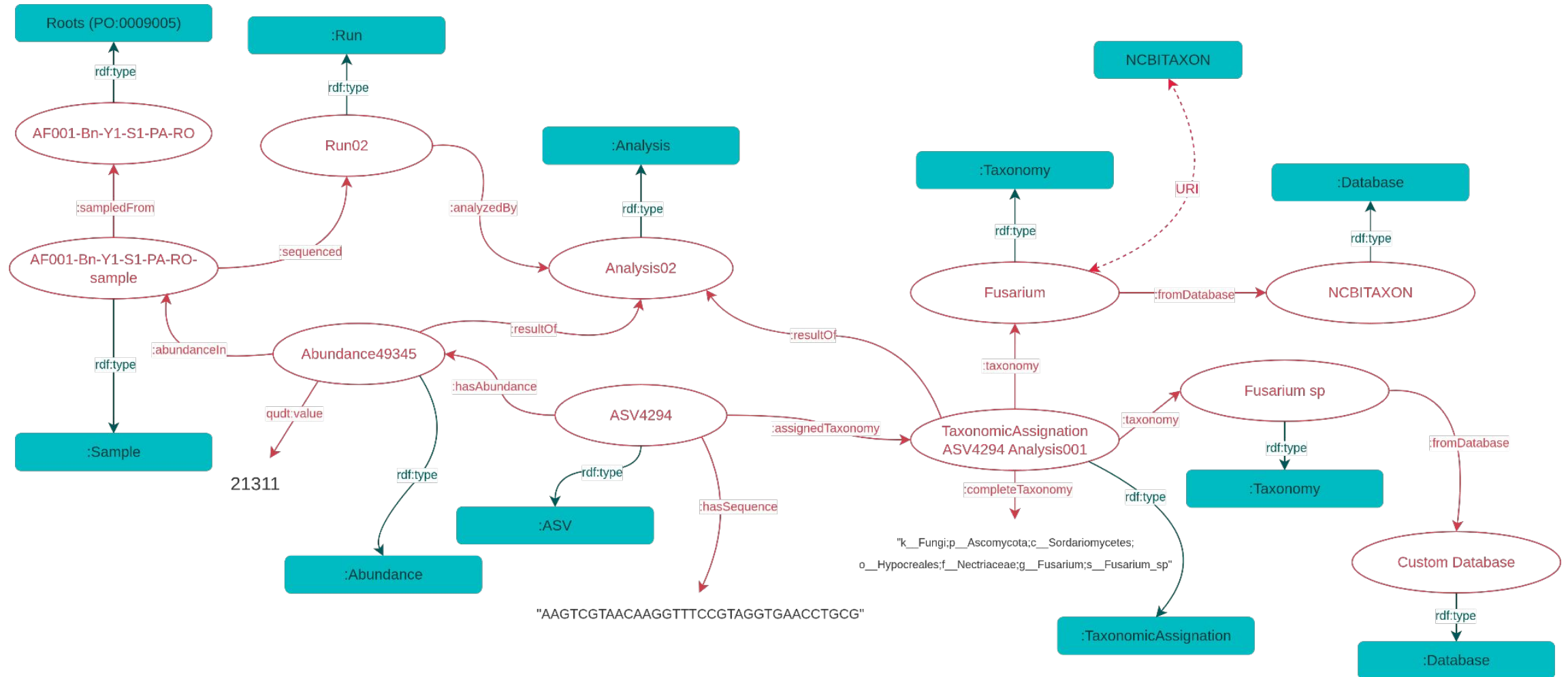
ASV modelization

Lowest taxon (or lowest taxon found in NCBITAXON)



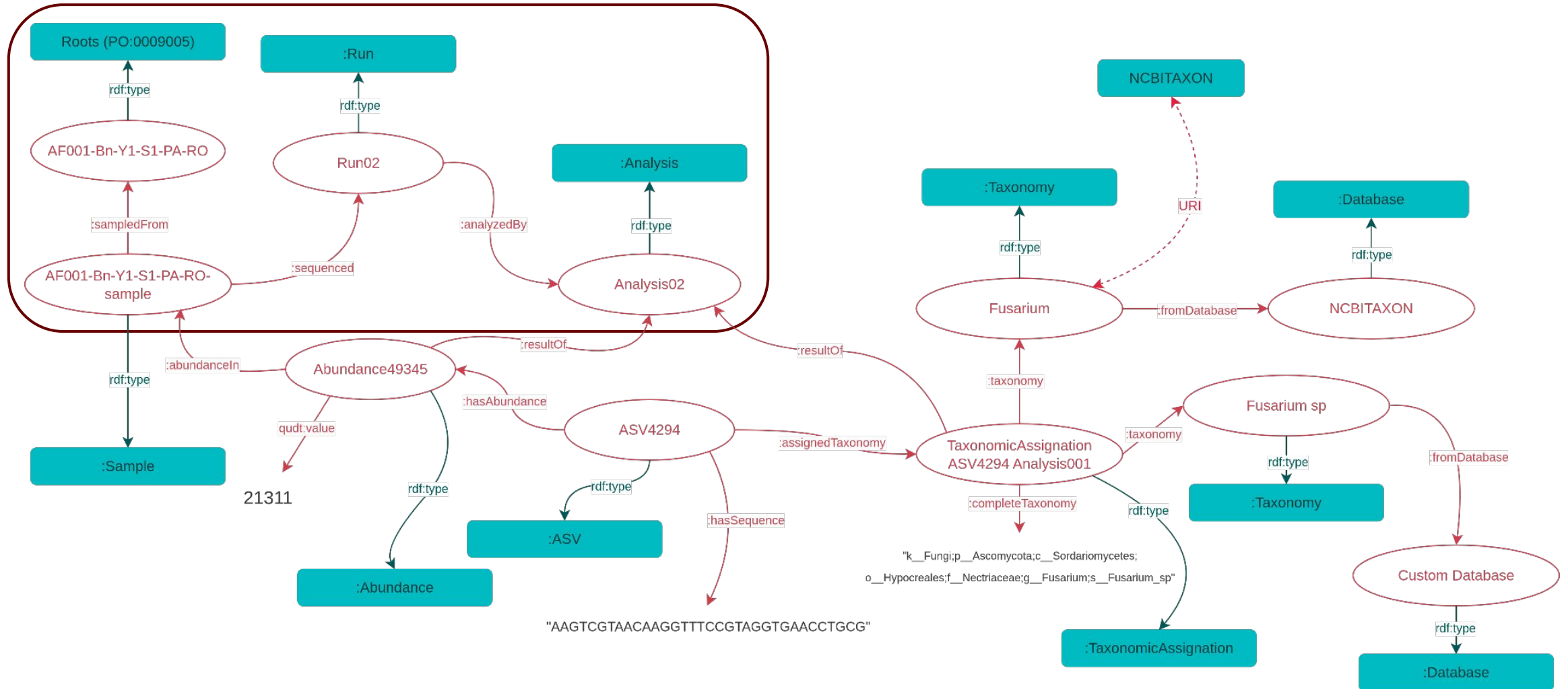
ASV modelization

Example - Abundance and taxonomic assignation of an ASV in root microbiota



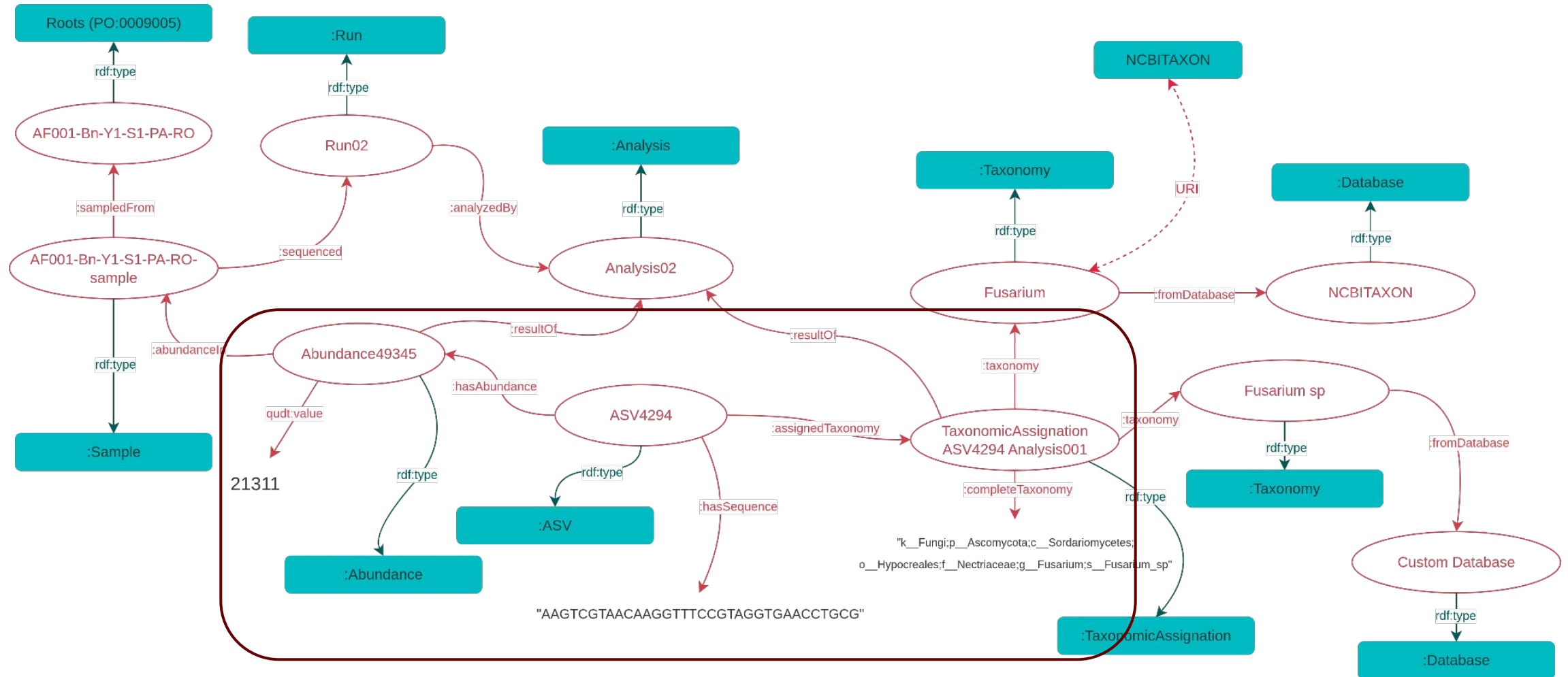
ASV modelization

Example - Abundance and taxonomic assignation of an ASV in root microbiota



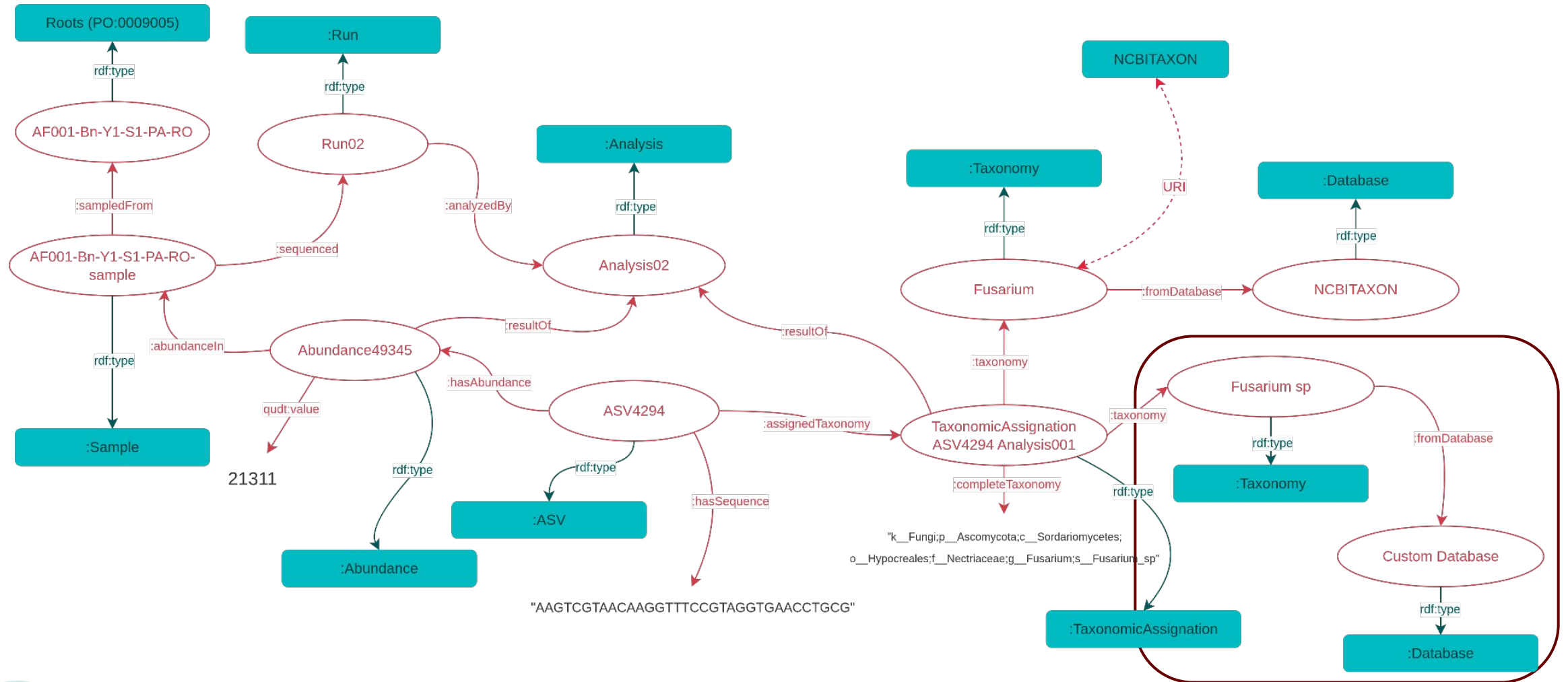
ASV modelization

Example - Abundance and taxonomic assignation of an ASV in root microbiota



ASV modelization

Example - Abundance and taxonomic assignation of an ASV in root microbiota

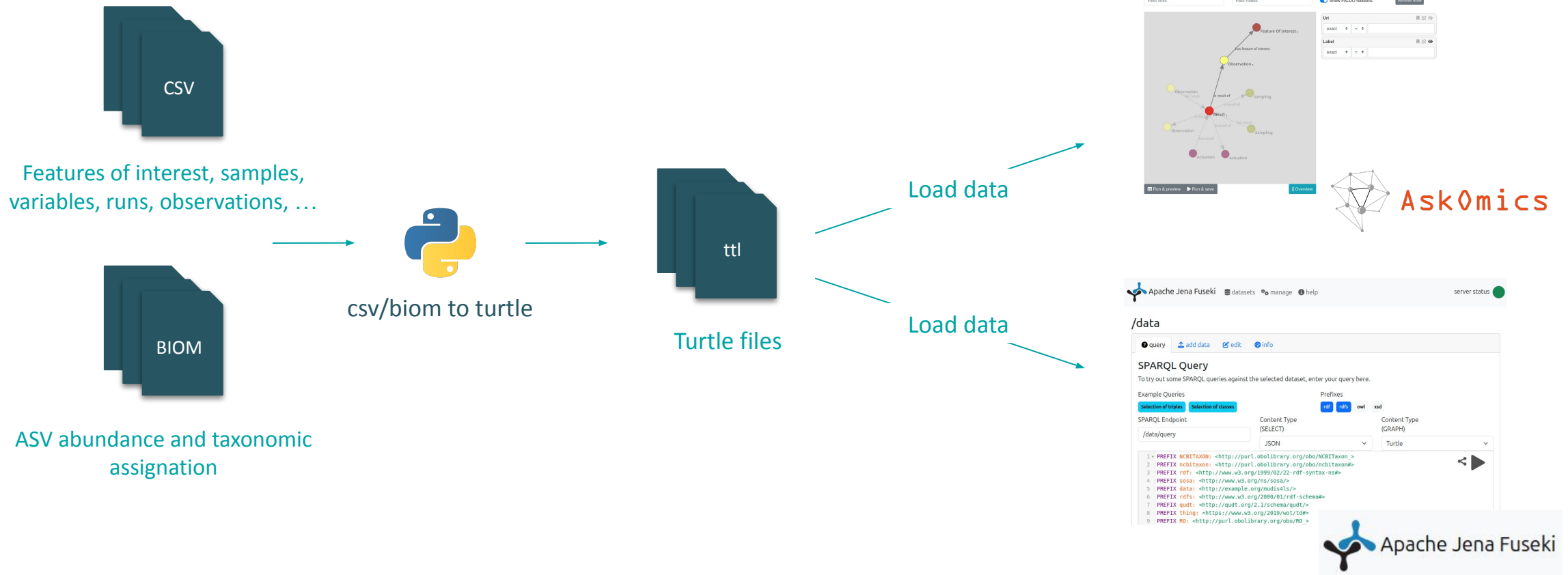


Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye



Data integration

Convert and load data

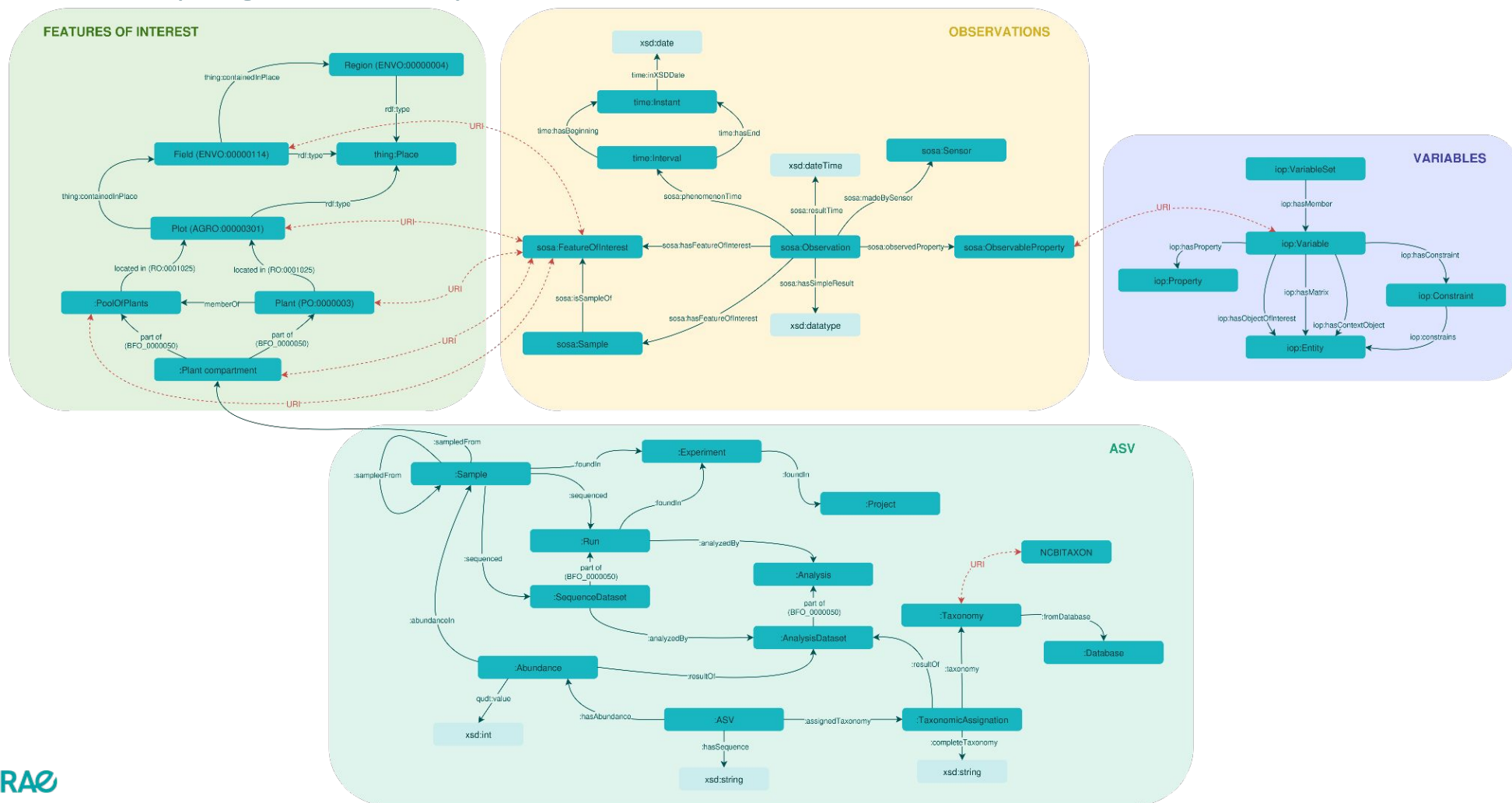


INRAE

Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye

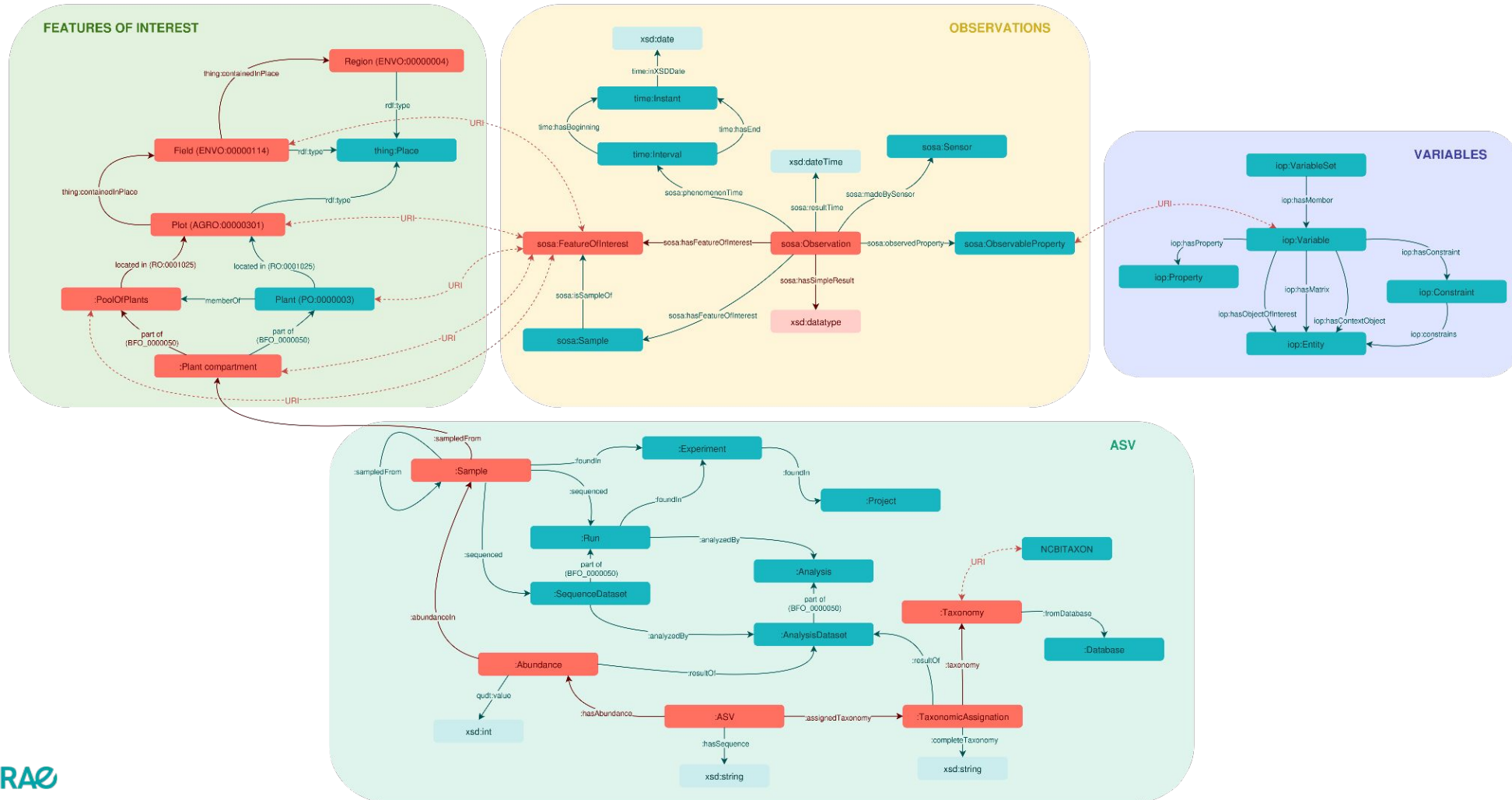
First SPARQL query

Taxa found in root microbiota of fields in western France under conventional agriculture in the 2nd sampling of the 2nd year



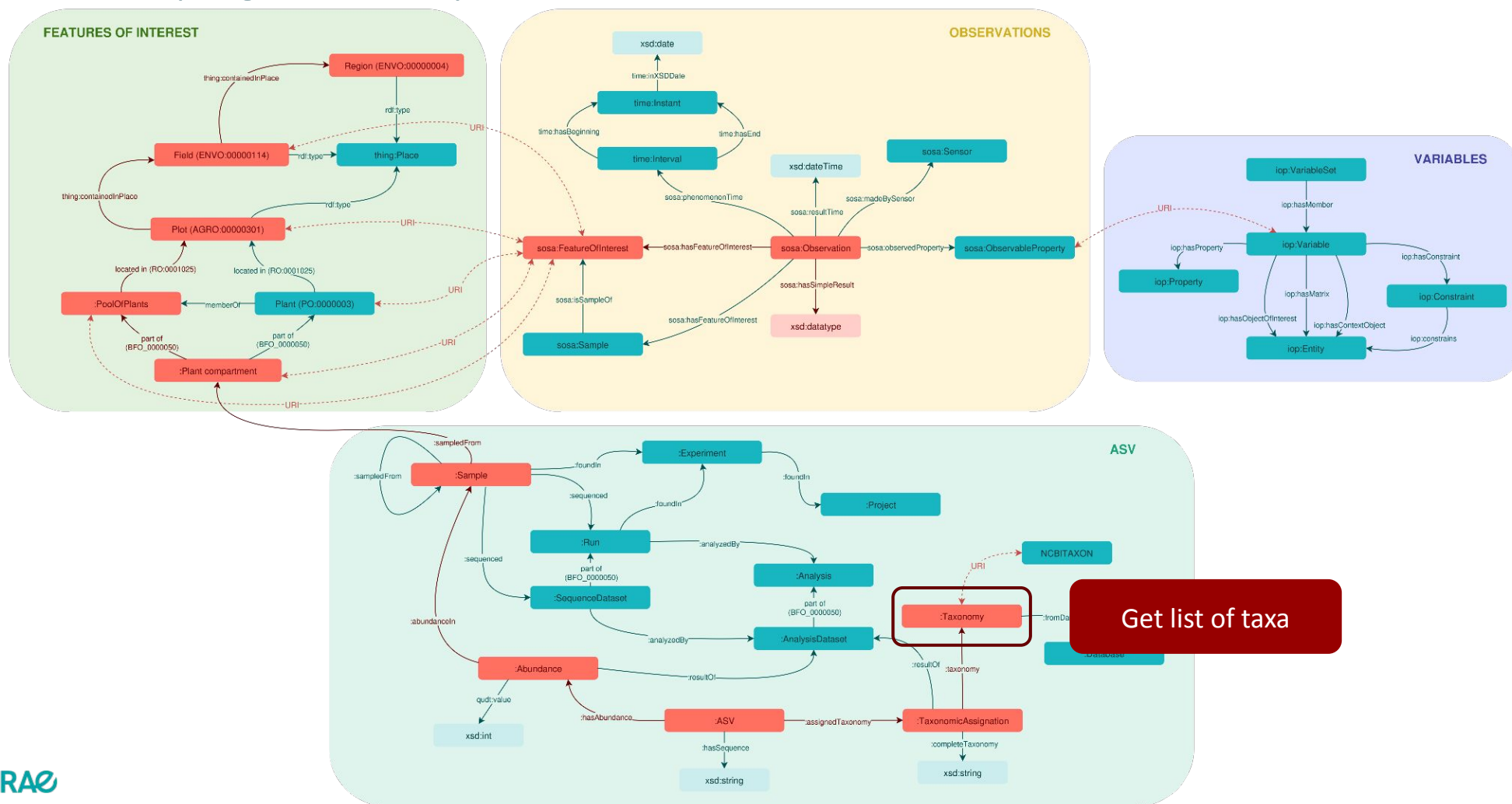
First SPARQL query

Taxa found in root microbiota of fields in western France under conventional agriculture in the 2nd sampling of the 2nd year



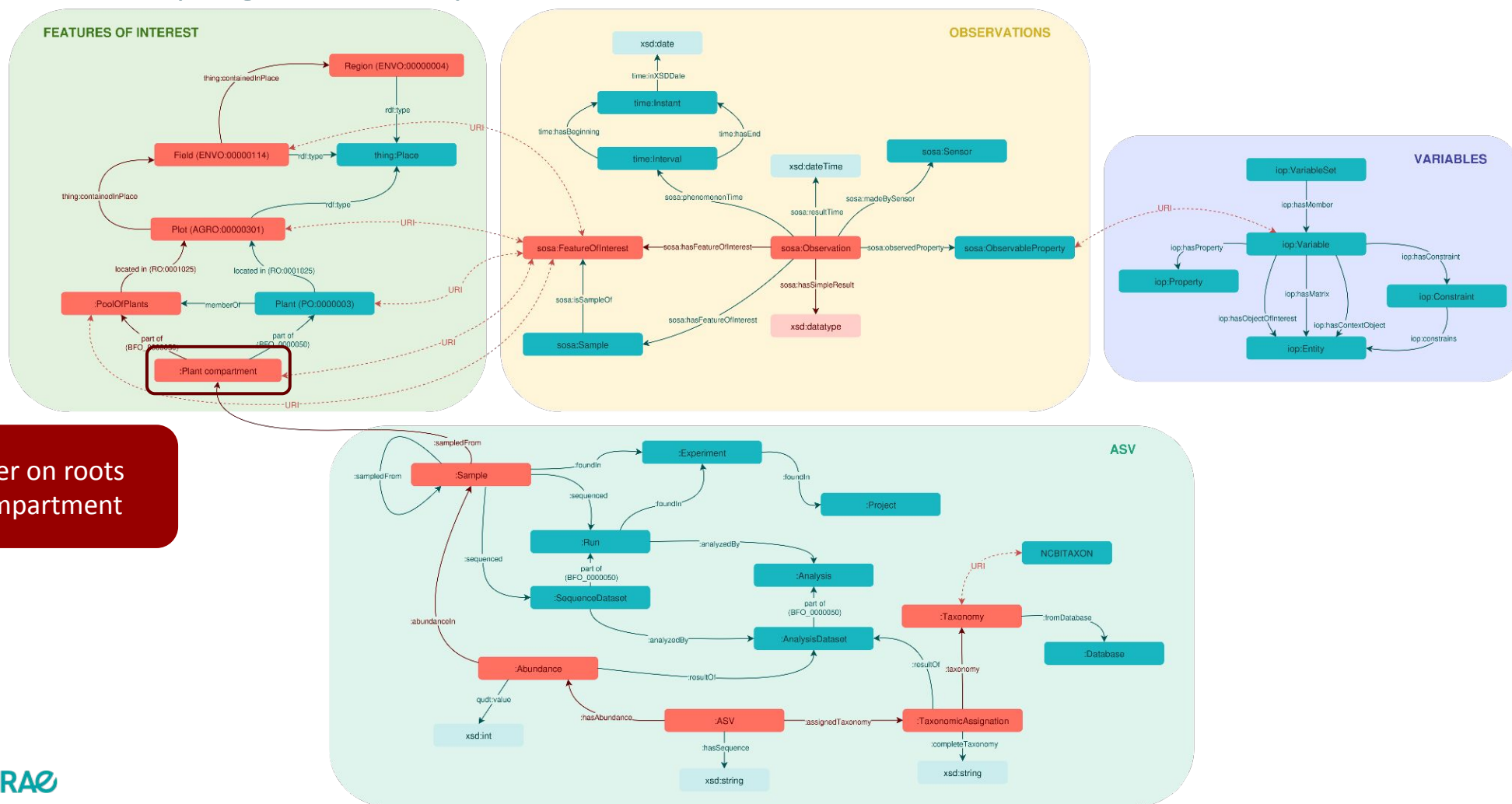
First SPARQL query

Taxa found in root microbiota of fields in western France under conventional agriculture in the 2nd sampling of the 2nd year



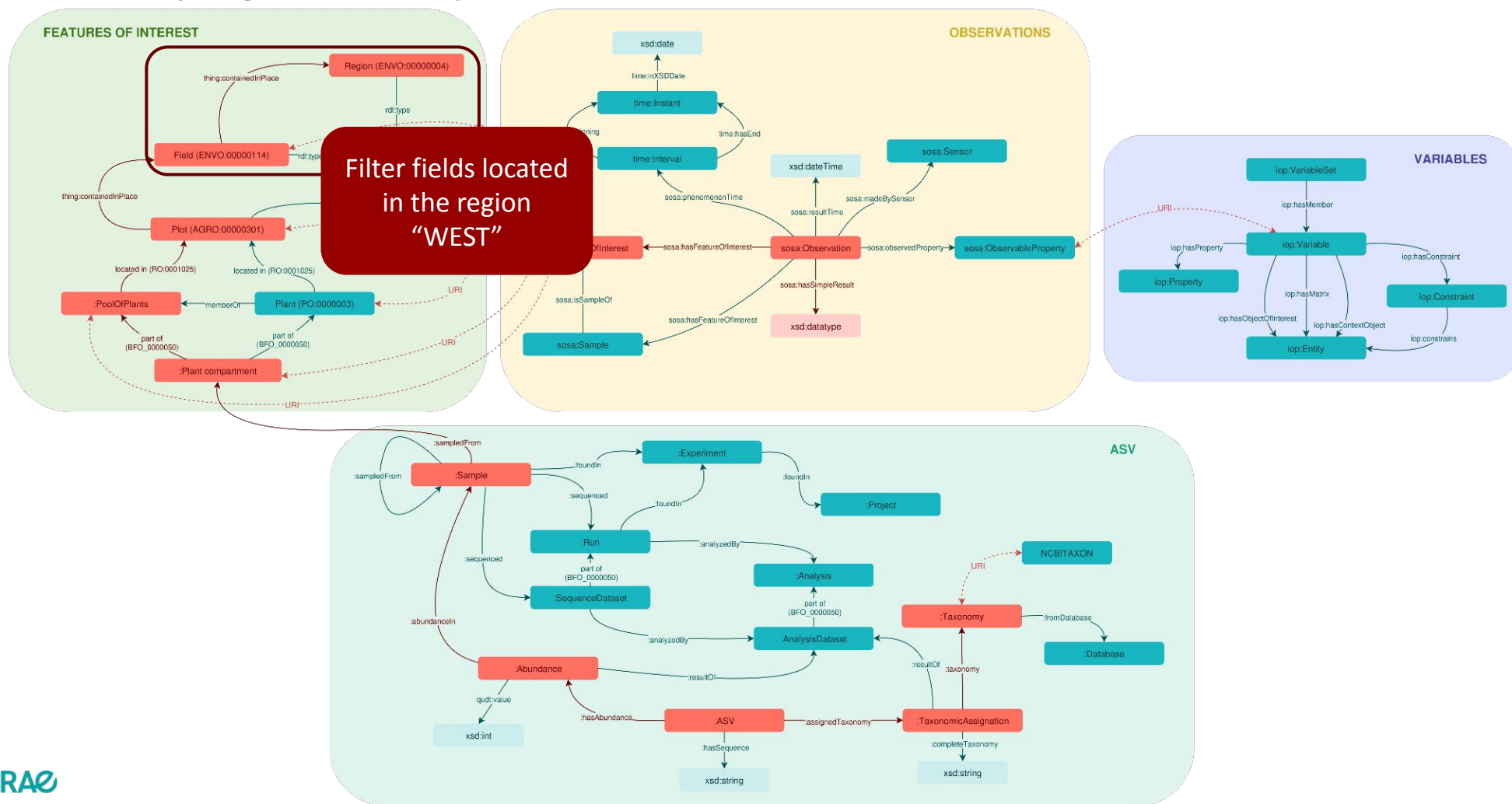
First SPARQL query

Taxa found in **root** microbiota of fields in western France under conventional agriculture in the 2nd sampling of the 2nd year



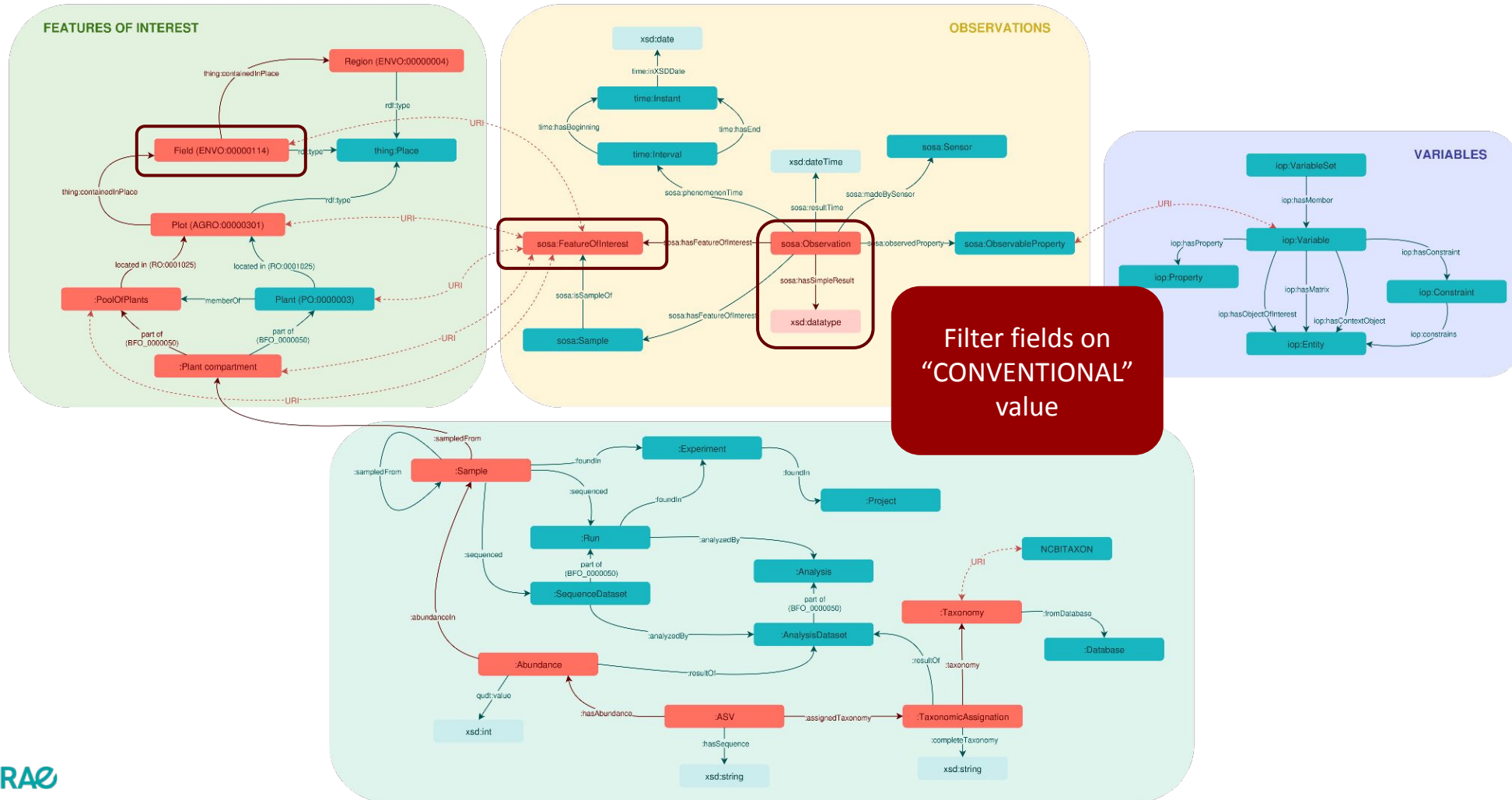
First SPARQL query

Taxa found in root microbiota of **fields in western France** under conventional agriculture in the 2nd sampling of the 2nd year



First SPARQL query

Taxa found in root microbiota of fields in western France under **conventional agriculture** in the 2nd sampling of the 2nd year



Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye



First SPARQL query

Taxa found in root microbiota of fields in western France under conventional agriculture in the 2nd sampling of the 2nd year

```
1 PREFIX NCBITAXON: <http://purl.obolibrary.org/obo/NCBITaxon_>
2 PREFIX ncbitaxon: <http://purl.obolibrary.org/obo/ncbitaxon#>
3 PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
4 PREFIX sosa: <http://www.w3.org/ns/sosa/>
5 PREFIX data: <http://example.org/mudis4ls/>
6 PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
7 PREFIX qudt: <http://qudt.org/2.1/schema/qudt/>
8 PREFIX thing: <https://www.w3.org/2019/wot/td#>
9 PREFIX RO: <http://purl.obolibrary.org/obo/RO_>
10 PREFIX PO: <http://purl.obolibrary.org/obo/PO_>
11 PREFIX BFO: <http://purl.obolibrary.org/obo/BFO_>
12
13 SELECT DISTINCT ?taxon_label
14 WHERE {
15     ?field thing:containedInPlace data:WEST .
16     ?obs sosa:hasFeatureOfInterest ?field ;
17         sosa:hasSimpleResult "CONVENTIONAL" .
18
19     ?plot thing:containedInPlace ?field .
20     ?plant RO:0001025 ?plot .
21     ?obs2 sosa:hasFeatureOfInterest ?plot ;
22         sosa:phenomenonTime data:Y2S2 .
23     ?plant_compartment rdf:type PO:0009005 ; #
24         BFO:0000050 ?plant .
25     ?sample sosa:isSampleOf ?plant_compartment ;
26         rdfs:label ?sample_label .
27
28     ?abundance data:abundanceIn ?sample .
29     ?asv data:assignedTaxonomy ?taxonomic_assignment ;
30         data:hasAbundance ?abundance .
31     ?taxonomic_assignment data:taxonomy ?taxonomy .
32     {
33         ?taxonomy data:fromDatabase <http://purl.obolibrary.org/obo/ncbitaxon.owl> ;
34         rdfs:label ?taxon_label ;
35         ncbitaxon:has_rank NCBITAXON:species .
36     }
37     UNION
38     {
39         ?taxonomy data:fromDatabase data:customDatabase ;
40         rdfs:label ?taxon_label .
41     }
42 }
```

Result

Table Response 1023 results in 13.091 seconds

taxon_label
1Olpidium brassicae
2Plectosphaerella oligotrophica
3Fungi sp
4Multi-affiliation
5Pleosporales sp
6Cladorrhinum phialophoroides
7Tubaria furfuracea
8Unclassified
9Devosia psychrophila
10Rhizobium leguminosarum
11Sphingomonas sp. Leaf242
12Polaromonas sp. JS666
13Rhizobacter sp. OV335
14Polaromonas sp. CF318
15Bacillus sp. FJAT-21352

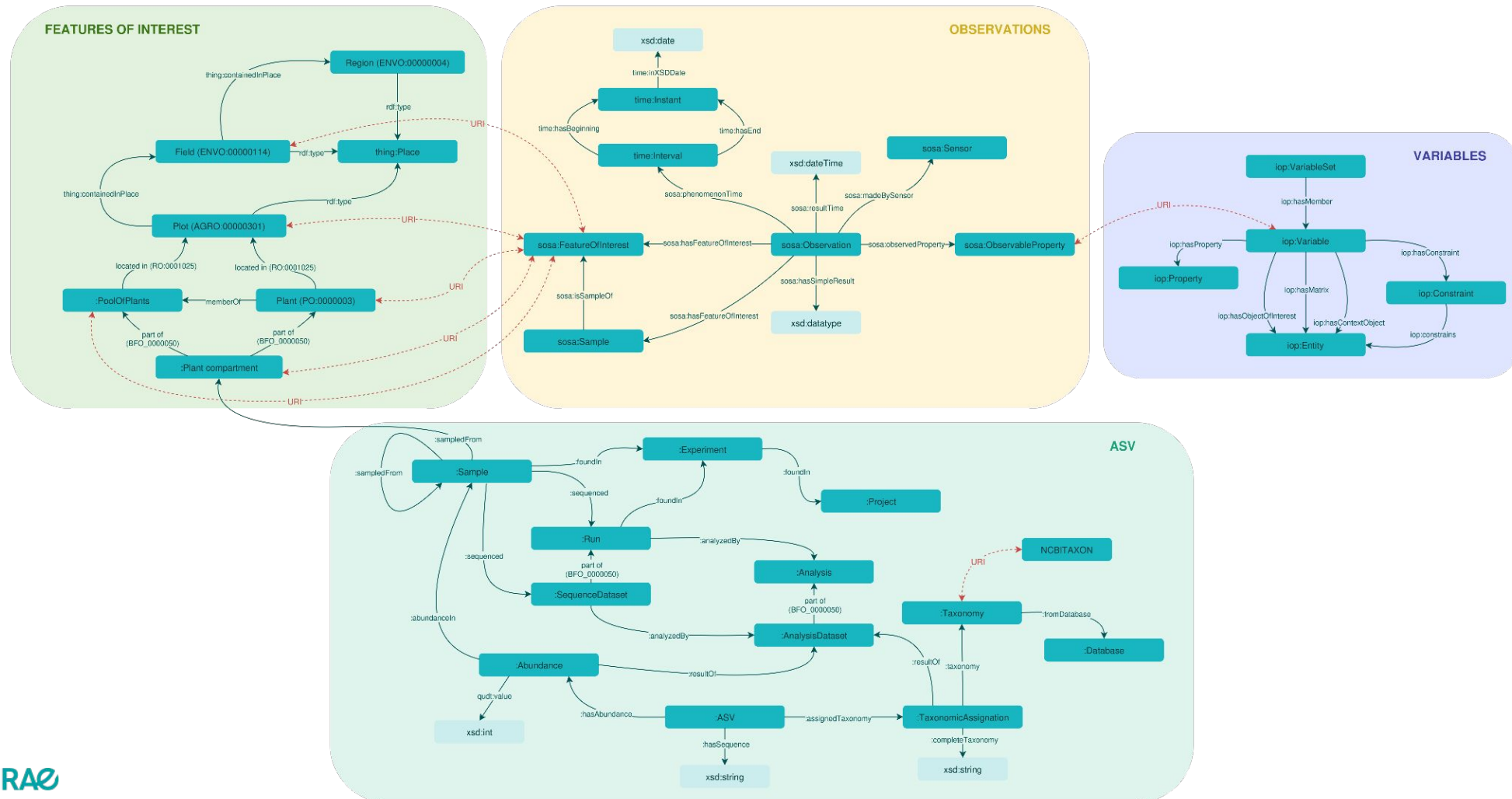


INRAE

Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye

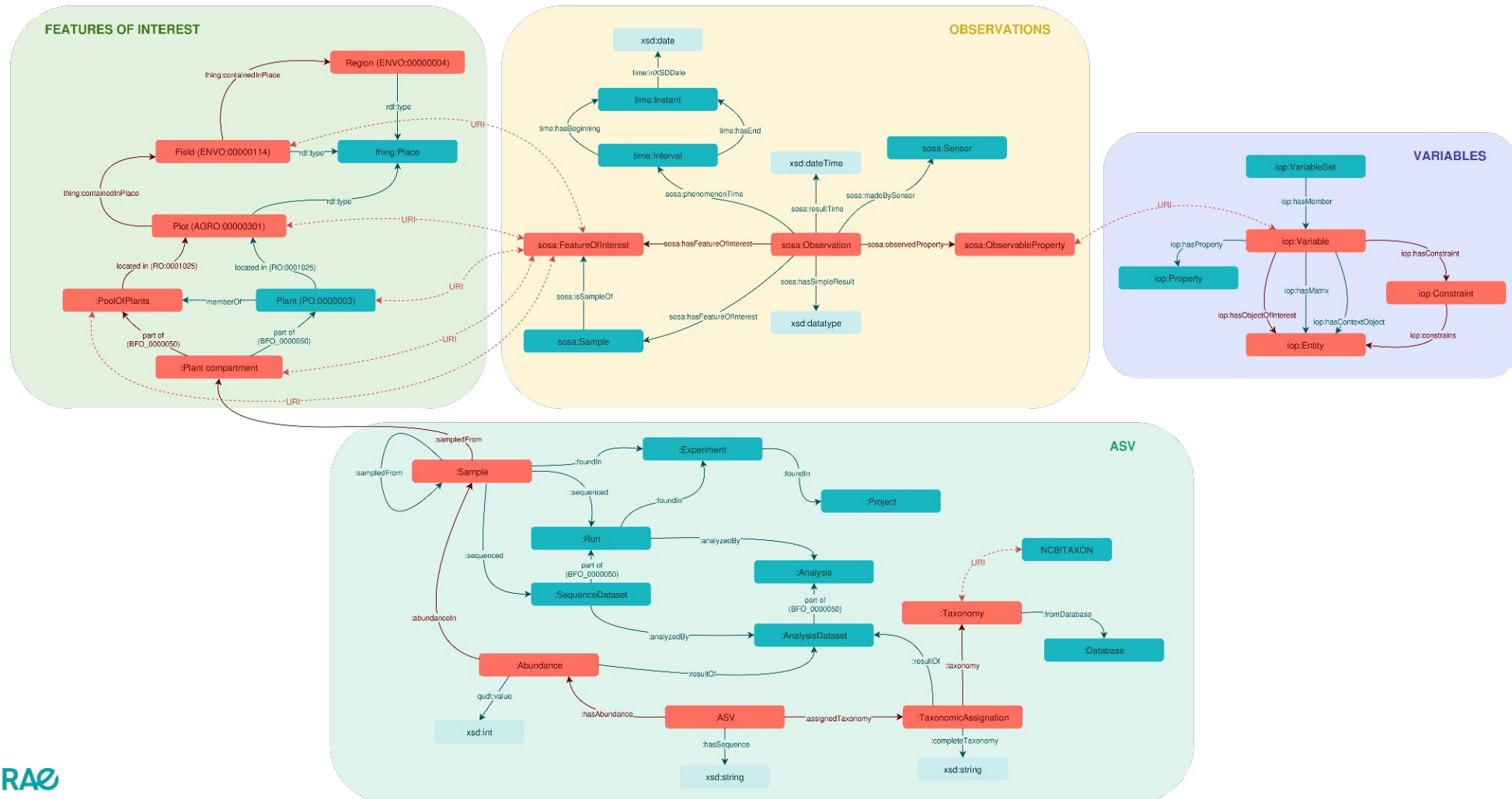
Second SPARQL query

Taxa found in the bulk soil of plots located in the regions East where the weeds CHEAL at the phenological stage D is present



Second SPARQL query

Taxa found in the bulk soil of plots located in Eastern France where the weed CHEAL at the phenological stage D was present



Holograph - A schema to describe holobionts in agroecology
PEPI IBIS days / 15 octobre 2025 / Marie Lahaye



Second SPARQL query

Taxa found in the bulk soil of plots located in Eastern France where the weed CHEAL at the phenological stage D was present

```
3 PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
4 PREFIX sosa: <http://www.w3.org/ns/sosa/>
5 PREFIX data: <http://example.org/mudis4ls/>
6 PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
7 PREFIX qudt: <http://qudt.org/2.1/schema/qudt/>
8 PREFIX thing: <https://www.w3.org/2019/wot/td#>
9 PREFIX RO: <http://purl.obolibrary.org/obo/RO_>
10 PREFIX ENVO: <http://purl.obolibrary.org/obo/ENVO_>
11 PREFIX BFO: <http://purl.obolibrary.org/obo/BFO_>
12 PREFIX iop: <https://w3id.org/iadopt/ont/>
13
14 SELECT DISTINCT ?taxon_label
15 WHERE {
16   ?field thing:containedInPlace data:EAST .
17   ?plot thing:containedInPlace ?field ;
18     rdfs:label ?plot_label .
19   ?obs sosa:hasFeatureOfInterest ?plot ;
20     sosa:observedProperty ?variable .
21   ?variable iop:hasObjectOfInterest data:CHEAL ;
22     iop:hasConstraint data:D .
23
24   ?plant RO:0001025 ?plot .
25   ?plant_compartment rdf:type ENVO:00005802 ; # bulk soil
26     BFO:0000050 ?plant . # part of
27   ?sample sosa:isSampleOf ?plant_compartment ;
28     rdfs:label ?sample_label .
29
30   ?abundance data:abundanceIn ?sample .
31   ?asv data:assignedTaxonomy ?taxonomic_assignment ;
32     data:hasAbundance ?abundance .
33   ?taxonomic_assignment data:taxonomy ?taxonomy .
34   {
35     ?taxonomy data:fromDatabase <http://purl.obolibrary.org/obo/ncbitaxon.owl> ;
36       rdfs:label ?taxon_label ;
37       ncbitaxon:has_rank NCBITAXON:species .
38   }
39   UNION
40   {
41     ?taxonomy data:fromDatabase data:customDatabase ;
42       rdfs:label ?taxon_label .
43   }
44 }
```

Result



Table Response 347 results in 0.701 seconds

taxon_label
1Olpidium brassicae
2Fusarium sp
3Verticillium dahliae
4Multi-affiliation
5Fungi sp
6Dichotomopilus erectus
7Chaetomium angustispirale
8Hypocreales sp
9Fusarium culmorum
10Plectosphaerella oligotrophica
11Cladosporium sp
12Monocillium mucidum
13Dichotomopilus pratensis
14Acrostalagmus luteoalbus
15Syncephalis sp
16Eurotiales sp

Perspectives

Queries

- Queries library
- Modules to generate complex SPARQL queries



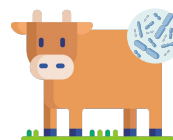
Web interfaces

-  AskOmicS
- Web interfaces to browse data and create graphical views



Model

- Livestock holobionts modelization



Acknowledgment

Alice Mataigne
Olivier Dameron
Yael Tirlet Greiner
Anne Siegel

Olivier Rué
Valentin Loux
Anne-Françoise Adam-Blondon

Fabrice Legeai
Matéo Boudet
Kévin Gazengel
Christophe Mougél
Lionel Lebreton

