RO-Crate and BioDT

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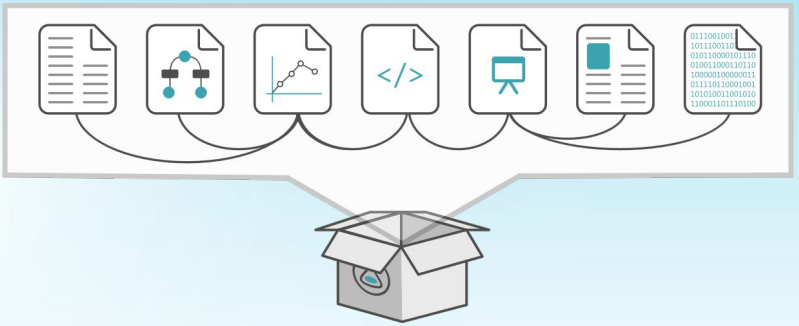
Funded by the European Union

https://doi.org/10.5281/zenodo.14036225

Aims of FAIR Research Objects

BIODT
biodiversitydigitaltwin



Describe and **package** data collections, datasets, software etc.

→ data moves with its **metadata**

Platform-independent object exchange between repositories and services

Support **reproducibility** and **analysis**: link data with codes and workflows

Transfer of **sensitive/large** distributed datasets with persistent identifiers

Aggregate **citations** and **persistent identifiers**

Propagate **provenance** and **existing metadata**

Publish and archive **mixed objects** and references

Reuse existing **standards**, but hide their complexity

research object.org

```
{
 "@id": "figure.png",
 "@type": ["File", "ImageObject"],
 "name": "XXL-CT-scan of an XXL Tyrannosaurus rex skull",
 "identifier": "https://doi.org/10.5281/zenodo.3479743",
 "author": {"@id": "https://orcid.org/0000-0002-8367-6908"},
 "encodingFormat": "image/png"
}
```

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 "@type": "Person",
 "affiliation": { "@id": "https://ror.org/03f0f6041" },
 "name": "J. Xuan"
}
```

```
{
 "@id": "https://ror.org/03f0f6041",
 "@type": "Organization",
 "name": "University of Technology Sydney",
 "url": "https://www.uts.edu.au/"
}
```

BIODT
biodiversitydigitaltwin

Linked Data.. by stealth

schema.org

JSON-LD

BIODT
biodiversitydigitaltwin

Species distribution models for Lycopodium

Download all the metadata for Species distribution models for Lycopodium in JSON-LD format

Check this crate

Species distribution models for Lycopodium

@id	./
name [?]	Species distribution models for Lycopodium
@type	Dataset
description [?]	Crop Wild Relatives distribution modeling workflow using ModGP for Lycopodium. Lycopodium is not not actually a crop species, but serves as a good test genus due to the limited amount of species in this genus (and thus the short workflow execution runtime). Lycopodium is a genus of clubmosses within the family Lycopodiaceae. These perennial, evergreen plants are characterized by their small, needle-like or scale-like leaves arranged in spirals or whorls along the stems. Lycopodium species reproduce via spores rather than seeds and often form dense mats in forests, particularly in moist, shaded environments.
datePublished [?]	2024-10-12T16:02:25.893Z
author [?]	Claus Weiland
conformsTo [?]	• https://w3id.org/ro/wfrun/process/0.1 • https://w3id.org/ro/wfrun/workflow/0.1 • https://w3id.org/workflowhub/workflow-ro-crate/1.0
dateCreated [?]	2024-10-12T16:02:27.337Z
dateModified [?]	2024-10-12T16:02:25.893Z
hasPart [?]	• Lycopodium_SDMData.RData • main.log • main.log • Lycopodium densum • Lycopodium deuterodensum • workflow.yaml
keywords [?]	• Lycopodium • ModGP • SDM • test • CWR
license [?]	https://spdx.org/licenses/CC-BY-SA-4.0

FAIR is not just machine-readable!

https://www.npmjs.com/package/ro-crate-html

RO-Crate in practice

RO-Crate is used by multiple international projects

Applied across research domains – from **life sciences** to **cultural heritage**

https://www.researchobject.org/ro-crate/use_cases

Arkisto

Arkisto was a project website that aimed to outline a principled approach to research data management.

Autosubmit

Autosubmit is an open source Python experiment and workflow manager used to manage complex workflows on Cloud and HPC platforms. Autosubmit uses RO-Crate to package the configuration, traces (logs, metrics, databases, etc.), and data of experiments and workflows.

BioConnect

JAX BioConnect is an index of research data that supports data sharing, high-quality curation, and consistent data description.

COMPSs

The COMPSs programming model is able to record Workflow Provenance in RO-Crate format, for governance and reproducibility of computational experiments

Data Plant

DataPLANT's mission is to provide a sustainable and well annotated data management platform for plant sciences.

Data Stewardship Wizard

The Data Stewardship Wizard (DSW) is an interactive platform for making data management plans

Dataverse & AROMA

AROMA (ARP RO-Crate Manager) is part of Hungarian initiative ELKH ARP, extending Harvard Dataverse to allow dynamic metadata editing of data deposit metadata.

DeSci Nodes

The DeSci Nodes system has been developed by the DeSci foundation, where dPID (distibuted Persistent Identifier) act as an overlay of the Interplanetary File System (IPFS)

EGI AppDB

EGI's Application Database (AppDB) has support for RO-Crate download, either as a JSON-LD metadata file or a ZIP archive.

FAIRSCAPE

FAIRSCAPE is a framework for reusable cloud-based computations using ARK identifiers with rich provenance in an evidence graph and the Evidence Graph Ontology (EVI)

Five Safes Crate

The Five Safes RO-Crate profile extend the Workflow Run RO-Crate profile for use in Trusted Research Environments (TRE).

KEDO Data Lake

Knowledge Enhanced Digital Objects (KEDO) is an experimental approach of building a data lake using a combination of knowledge graphs, RO-Crate and PID records.

Language Data Commons of Australia

LDaCA uses RO-Crate as an interchange and archive format for language data, and is providing data discovery portals and API access to data using RO-Crate-centric APIs.

Life Monitor

Life Monitor is a testing and monitoring service for computational workflows being developed as part of the EOSC-Life project. It aims to facilitate the execution, monitoring and sharing of workflow tests over time, allowing to detect deviations from expected workflow operation and provide useful feedback to the workflow authors

LivePublication

LivePublication is a proof of concept of an executable paper, which interactive visualization and statistical calculations can be regenerated on the fly taking into consideration data sources updated after the paper's publication date.

Machine-actionable data management plans

RDA maDMP Mapper and Ro-Crate_2ma-DMP can convert between machine-actionable data management plans (maDMP) and RO-Crate.

PARADISEC

Pacific and Regional Archive for Digital Sources in Endangered Cultures (PARADISEC) holds 16,100 hours of audio recordings and 2,800 hours of video recordings that might otherwise have been lost. These recordings are of performance, narrative, singing, and other oral tradition. This amounts to over 220 terabytes, and represents 1,370 languages, mainly from the Pacific region.

PILARS

PILARS is a set of Protocols for Implementing Long-term Archival Repository Services

ROHub

ROHub is a solution for the storage, lifecycle management and preservation of scientific work and operational processes via research objects. It makes these resources available to others, allows to publish and release them through a DOI, and allows to discover and reuse pre-existing scientific knowledge.

RRkive

RRKive is a website aimed to outline a principled approach to research data management with guidance on data storage and metadata

Research Object Composer

Research Object Composer is a REST API for gradually building and depositing Research Objects according to a pre-defined profile.

Sciebo RDS

Sciebo RDS (Research Data Services) is a self-hosted interface between data repositories and file storage solutions, assisting the research data deposition process with annotations made using Describo Online and stored as an RO-Crate

Survey Ontology

The Survey Ontology is an open vocabulary that allows representing, annotating and sharing a representation of the survey structure and the gathered responses.

Time Layered Cultural Map (TLCMap)

TLCMap is a set of tools that work together for mapping Australian history and culture which includes downloads of geographical data packaged in RO-Crate

UTS Cultural Datasets

The UTS Cultural Datasets project is collaborating with Humanities and Social Science (HASS) researchers and is re-using existing UTS Data infrastructure to build interactive services that allow people to use the data.

UTS Research Data Repository

The UTS Research Data Repository is a searchable portal for discovering and accessing public datasets by UTS researchers.

Wildlive portal

Senckenberg's Wildlive data portal, is a repository and analysis platform for biodiversity monitoring.

Workflow Execution Service (WfExS)

WfExS-backend is a high-level workflow execution command line program that consumes and creates RO-Crates, focusing on the interconnection of content-sensitive research infrastructures for handling sensitive human data analysis scenarios

WorkflowHub

WorkflowHub imports and exports Workflow RO-Crates, using it as an exchange format. They are a specialization of RO-Crate for packaging an executable workflow with all necessary documentation. It is aligned with, and intends to strictly extend, the more general Bioschemas ComputationalWorkflow profile.

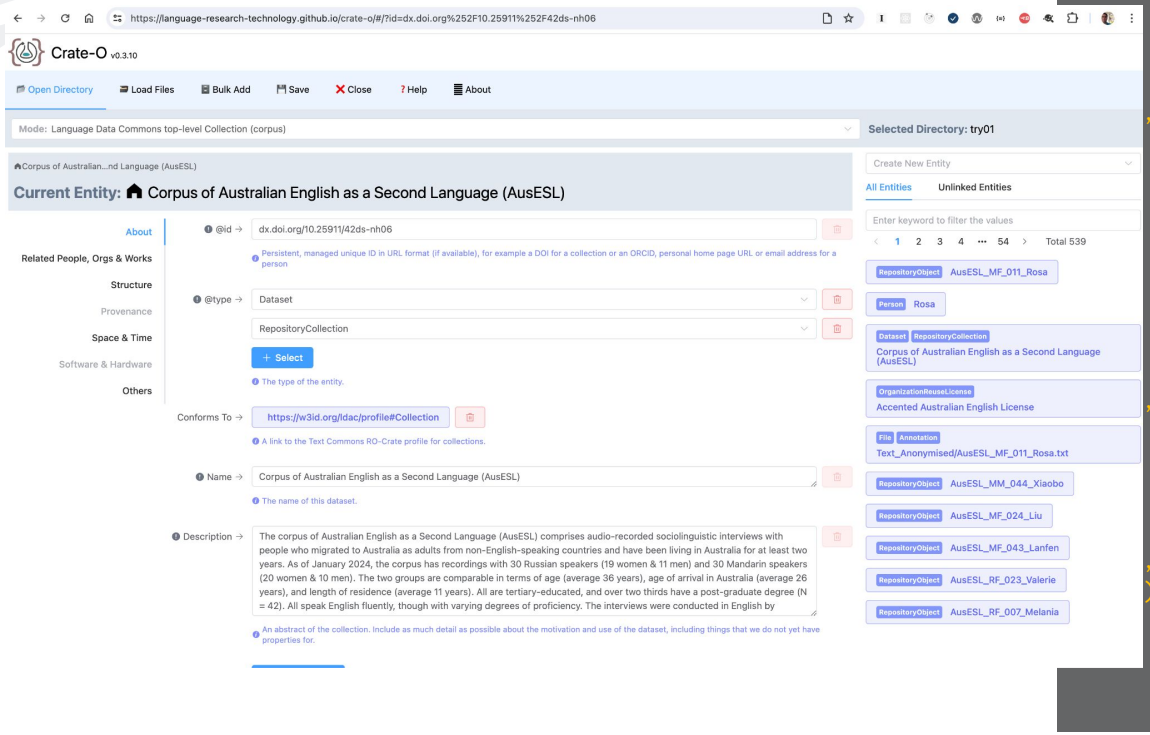
ZBMed SemTec web pages

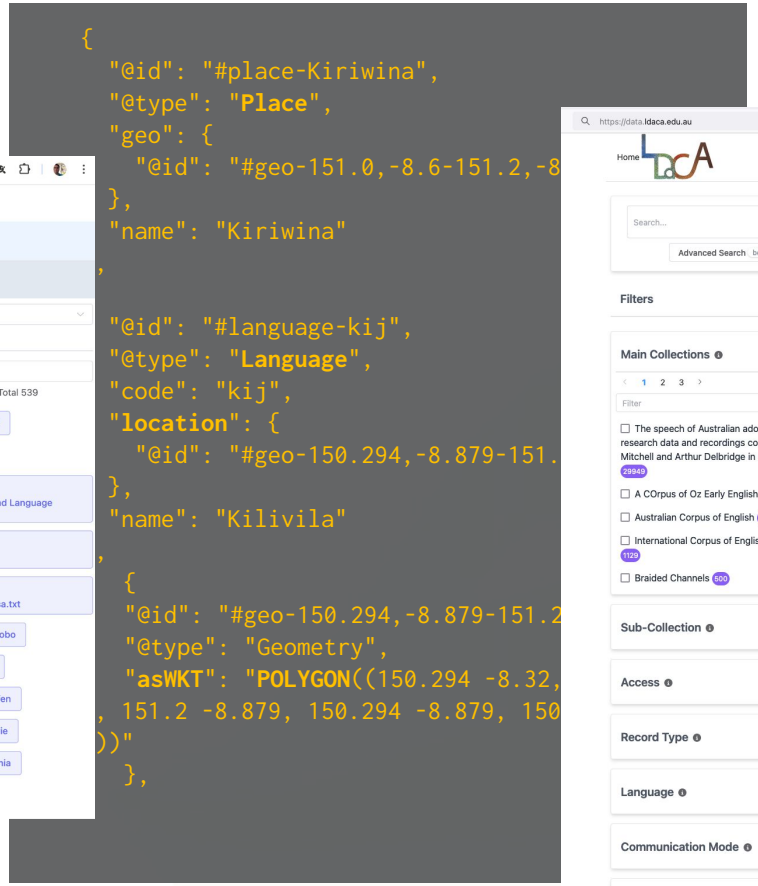
The Semantic Technologies (SemTec) team in ZB MED uses GitHub pages to share research projects and corresponding research artefacts/outcomes.

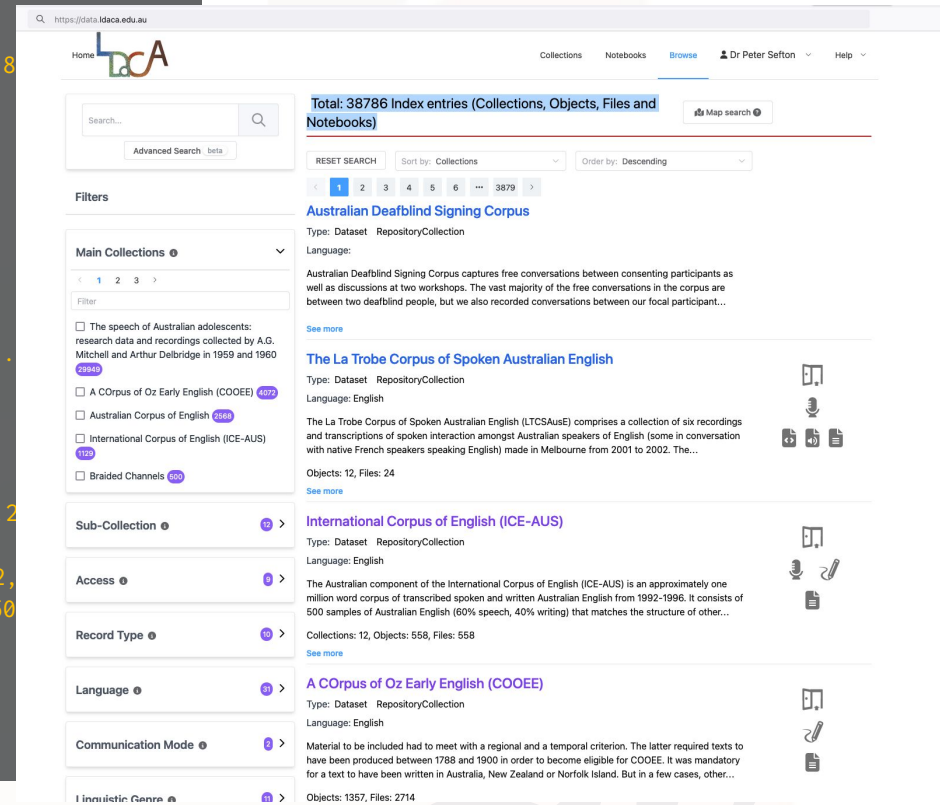
Collecting corpora for a Language Data Commons

BIODT biodiversitydigitaltwin

THE UNIVERSITY OF QUEENSLAND AUSTRALIA







https://youtu.be/p-GZbe-Kzww

atap australian text analytics platform atap.edu.au

https://www.researchobject.org/ro-crate/ldaca

https://www.researchobject.org/ro-crate/paradisec

https://earth-system.usegalaxy.eu

Galaxy | Earth System — Workflow | Visualize | Data | Help | User

Tools

search tools

- Get Data
- Send Data
- Collection Operations

GENERAL TEXT TOOLS

- Text Manipulation
- Filter and Sort
- Join, Subtract and Group
- Convert Formats
- Annotation
- Climate Analysis

GENERAL INTERACTIVE TOOLS

- Interactive tools

EARTH AND ENVIRONMENTAL DYNAMICS

- Water Coastal Dynamics
- Earth Critical Zone
- Volcano

ENVIRONMENTAL BIO-GEOCHEMICAL ASSETS

- Bio-geochemical

BIODIVERSITY OBSERVATION

- Marine Omics
- Biodiversity data exploration
- **DIVAnd** Data-Interpolating Variational Analysis in n dimensions

eosc | FAIR-EASE

Welcome to Galaxy for Earth System and environment

Galaxy for Earth System and environment was implemented within the project **Fair-Ease**. It's a virtual platform to process, analyse and visualize Earth System, Environment and Biodiversity data. It is based on the Galaxy framework, which guarantees simple access, easy extension, flexible adaption to personal and security needs, and sophisticated analyses independent of command-line knowledge.

Content

https://earth-system.usegalaxy.eu/

History

search datasets

Marine Omics: SMBGC annotation

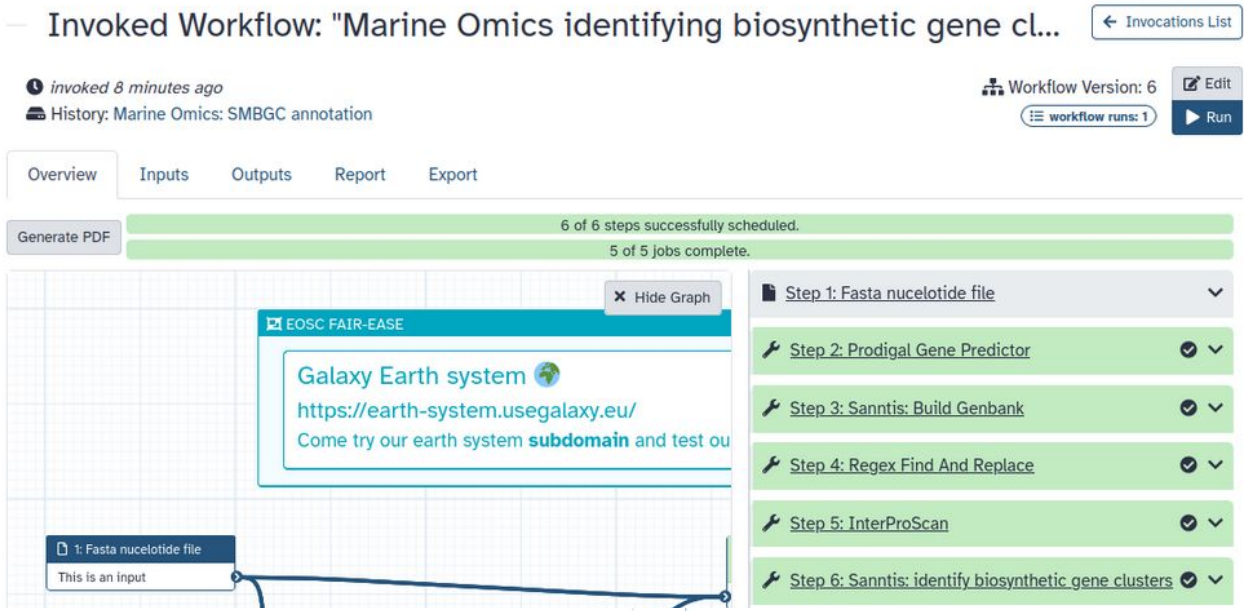
2.01 MB — 18

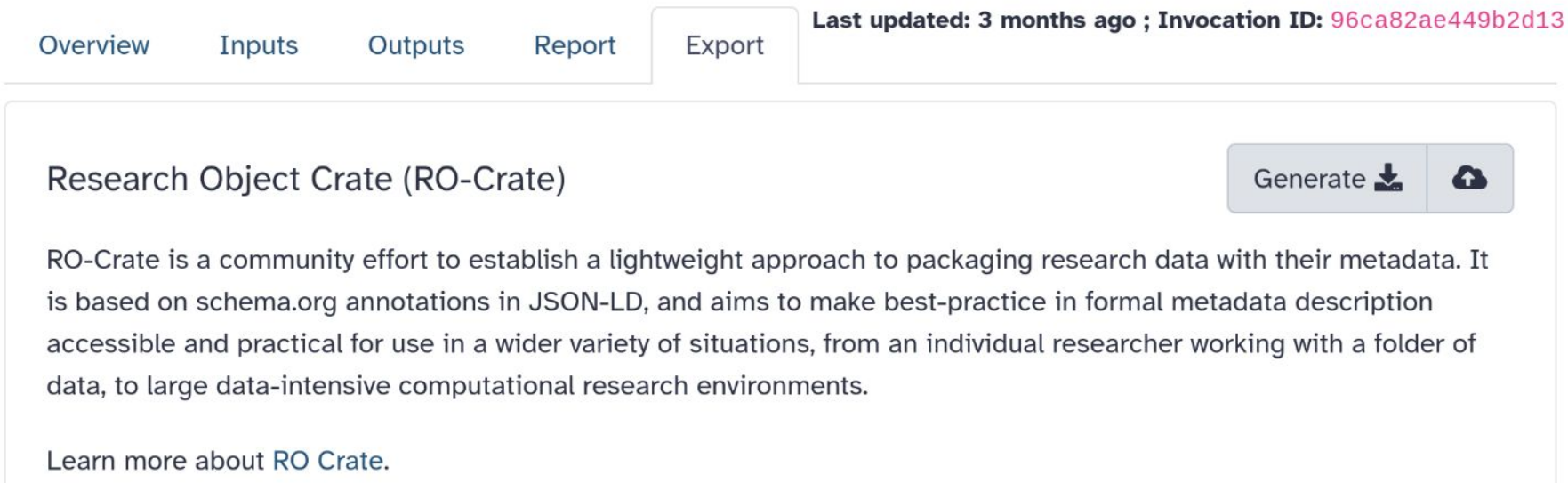
- 26: **48574534**
- 25: **Sanntis output data**
- 24: **InterProScan on data 23 (tsv)**
- 23: **Regex Find And Replace on data 19**
- 22: **Sanntis output data genbank**
- 21: **Prodigal Gene Predictor on data 15 : complete starts file**
- 20: **Prodigal Gene Predictor on data 15 : nucleotide sequences file**
- 19: **Prodigal Gene Predictor on data 15 : protein translations file**
- 18: **Prodigal Gene Predictor on data 15 : coordinates**
- 17: **Sanntis output data**
- 16: **InterProScan on data 15 (tsv)**

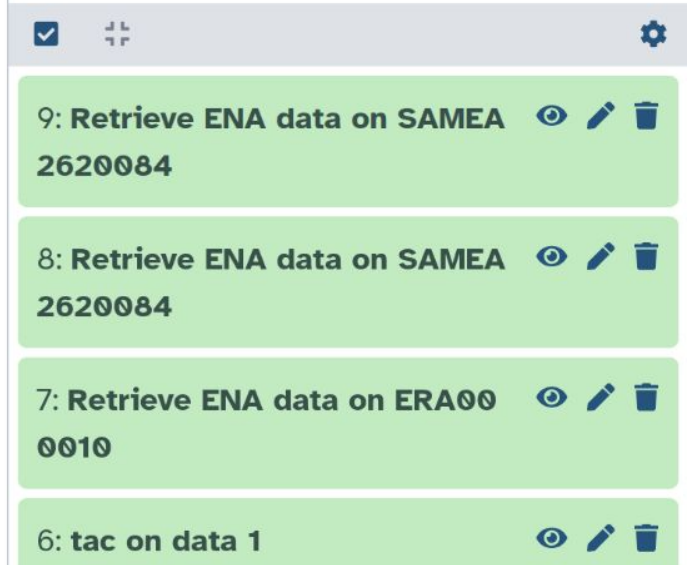
Exporting a workflow invocation in RO-Crate

- Run the workflow

- Galaxy saves all the analytical steps of the workflow in your history







Workflow systems in BioDT

Nextflow: Assisting developers for RO-Crate of runs and from nf-core

Snakemake: With BGE adding RO-Crate of runs

pydoit: Created https://github.com/BioDT/pydidit

Lexis: Exploring two strands:

a) Creating RO-Crate as part of workflow
b) Airflow engine to save provenance of workflow execution

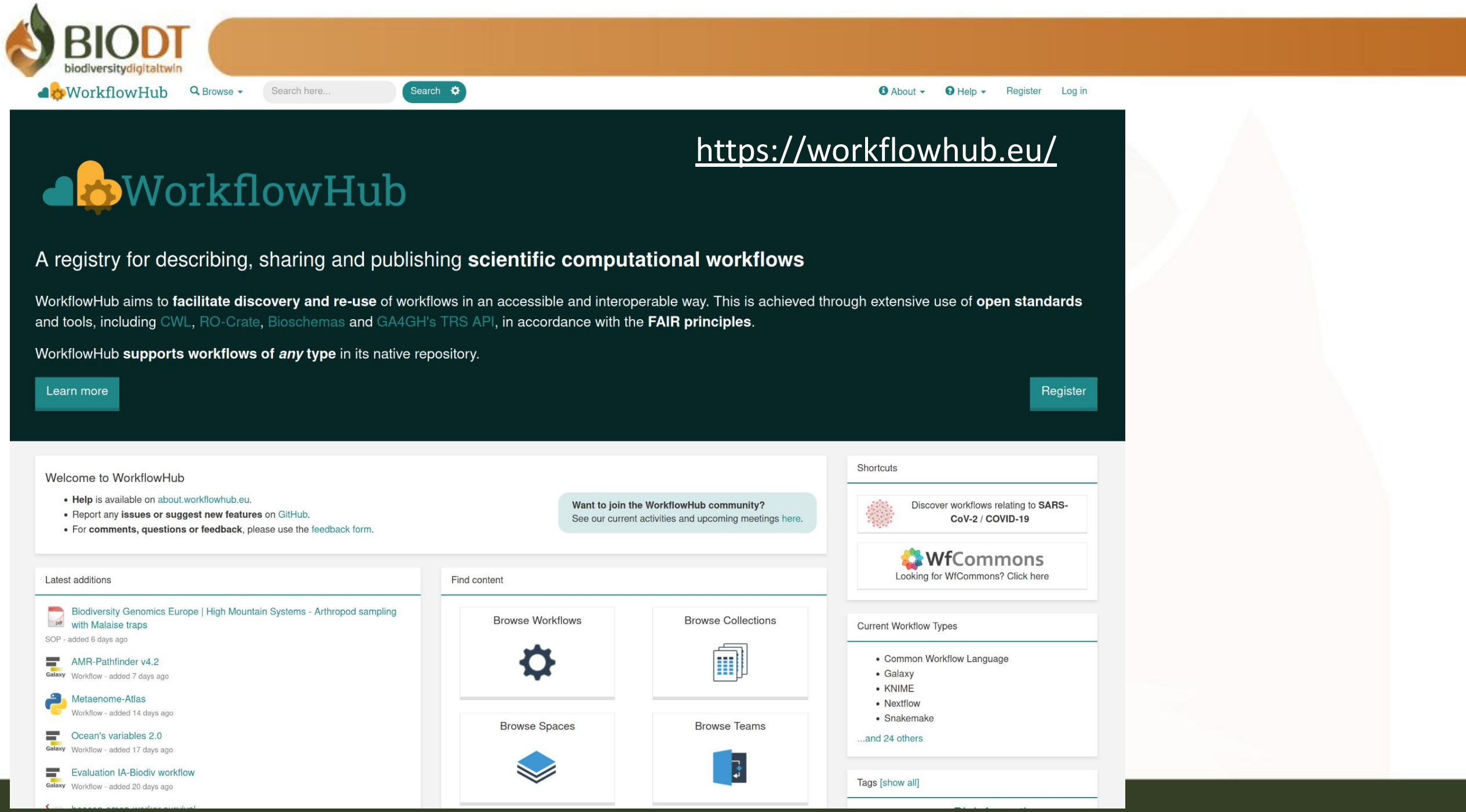
"Manual" workflows: Choose a template, use Crate-O editor, and upload to WorkflowHub

RO-Crate native: DestinE Platform – evaluate Galaxy, WfExS?

Implementations & examples

Several workflow engines have implemented the WRROC profiles or are planning to do so:

Implementation	Profile	Version URL/DOI	Example
runcrate	Provenance	runcrate 0.5.0 or later	10.5281/zenodo.7774351
Galaxy	Workflow	Galaxy 23.1.1 or later	10.5281/zenodo.7785861
COMPSs	Workflow	compss 3.2 or later	10.5281/zenodo.7788030
StreamFlow	Provenance	Streamflow 0.2.0.dev10	10.5281/zenodo.7911906
WfExS	Workflow	WfExS 0.10.1 or later	10.5281/zenodo.10091550
Sapporo	Workflow	sapporo-service 1.5.1 or later	10.5281/zenodo.10134581
Autosubmit	Workflow	Autosubmit v4.0.100 or later	10.5281/zenodo.8144612
Nextflow	Provenance	(nf-prov in development)	example


BIODT
biodiversitydigitaltwin
WorkflowHub
Browse
Search here...
Search
About
Help
Register
Log in
https://workflowhub.eu/
WorkflowHub
A registry for describing, sharing and publishing scientific computational workflows
WorkflowHub aims to facilitate discovery and re-use of workflows in an accessible and interoperable way. This is achieved through extensive use of open standards and tools, including CWL, RO-Crate, Bioschemas and GA4GH's TRS API, in accordance with the FAIR principles.
WorkflowHub supports workflows of any type in its native repository.
Learn more
Register
Welcome to WorkflowHub
Help is available on about.workflowhub.eu.
Report any issues or suggest new features on GitHub.
For comments, questions or feedback, please use the feedback form.
Want to join the WorkflowHub community?
See our current activities and upcoming meetings here.
Shortcuts
Discover workflows relating to SARS-CoV-2 / COVID-19
WfCommons
Looking for WfCommons? Click here
Latest additions
Biodiversity Genomics Europe | High Mountain Systems - Arthropod sampling with Malaise traps
SOP - added 6 days ago
AMR-Pathfinder v4.2
Workflow - added 7 days ago
Metaenome-Atlas
Workflow - added 14 days ago
Ocean's variables 2.0
Workflow - added 17 days ago
Evaluation IA-Biodiv workflow
Workflow - added 20 days ago
Find content
Browse Workflows
Browse Collections
Browse Spaces
Browse Teams
Current Workflow Types
Common Workflow Language
Galaxy
KNIME
Nextflow
Snakemake
...and 24 others
Tags [show all]

Share and version my workflow

WorkflowHub | Browse | Create | Search here... | Search | About | Help | My Items | Marie Jossé

Workflow was successfully uploaded and saved.

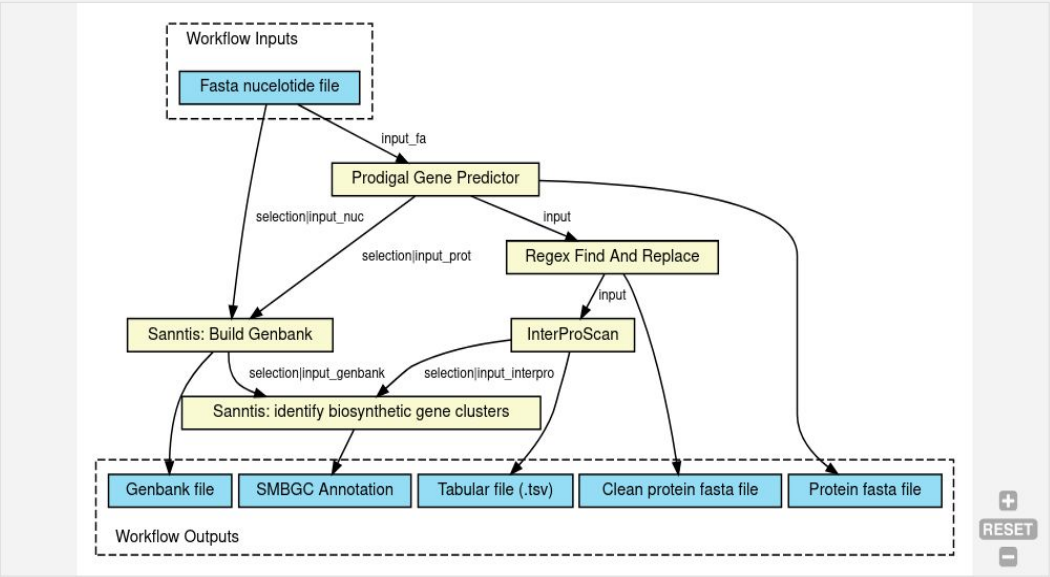
Marine Omics identifying biosynthetic gene clusters Version 1

Subscribe | Download RO-Crate | Run on Galaxy | Add new | Actions

Overview | Files | Related items

Workflow Type: Galaxy

Secondary metabolite biosynthetic gene cluster (SMBGC) Annotation using Neural Networks Trained on Interpro Signatures



Click and drag the diagram to pan, double click or use the controls to zoom.

Creators and Submitter

Creator
Marie Jossé

Submitter
Marie Jossé

Tool

Prodigal

Citation

Make your Workflow easily citable by generating a DOI for it.

This Workflow version must be frozen before being eligible for a DOI.

Freeze version

Version History

Version 1 (earliest) Created 21st Aug 2024 at 09:17 by Marie Jossé

No revision comments

Open | master | cd239c1

eosc

FAIR-EASE

Building Interoperable Earth Science & Environmental Services

WorkflowHub Browse Create Search here... Search

BioDT

Overview | Related items

Related items

People (4) | Teams (9) | Organizations (4) | SOPs (1) | Presentations (1) | Workflows (2)

BioDT additional pipelines

BioDT pipelines not associated with one of the BioDT use cases.

Space: BioDT
Public web page: *Not specified*

BioDT Use Case 4.1.1.1 Biodiversity dynamics

Part of T.4.1.1 *Species response to environmental change* (UFZ, GBIFS, UKCEH, JYU, MLU)

Space: BioDT
Public web page: *Not specified*

BioDT Use Case 4.1.3.1 Invasive species

Part of T.4.1.3 Dynamics and threats from and for species of policy concern (UFZ, GBIFS, Naturalis, UKCI

Space: BioDT
Public web page: *Not specified*

BioDT Use Case 4.1.1.2 Ecosystem services

BioDT Guide to using WorkflowHub Version

Overview | Related items

The BioDT project is producing and maintaining workflows. We need to register those workflows in Workf

1. To give visibility to the workflows created by the project and by the different networks and communitie
2. To give visibility to the workflows used by project that were created
3. To share workflows across the project, within project networks and externally
4. To credit and cite the people making the workflows and the networks to which they belong
5. To track the versions of workflows as they are produced, and
6. To retain the workflows for post-project use by the networks

This project-specific guide shows how the BioDT will make use of WorkflowHub, such as navigating the B

SEEK ID: https://workflowhub.eu/sops/14?version=1

Link: https://docs.google.com/document/d/1B-kXTUrmhGy5ZmOfTAxCbN5Tg_NIAUYaEdIw8v28hi4/edit

DOI: 10.48546/workflowhub.sop.14.1

https://doi.org/10.48546/workflowhub.sop.14.1
https://www.youtube.com/watch?v=380EwriHzHc

pDT examples

https://github.com/BioDT/biodt-fair

Grassland Dynamics - Schrankogel (Austria) - 1994, 2004, 2014

@id	./
name [?]	Grassland Dynamics - Schrankogel (Austria) - 1994, 2004, 2014
@type	Dataset
description [?]	Species cover according to the GLORIA Field Manual: https://gloria.ac.at/downloads/Manual_5thEd_ENG.pdf (p 38); %;1x1m plots arranged in transects at southern slopes of Mt. Schrankogel: https://nph.onlinelibrary.wiley.com/doi/10.1111/nph.15290;visual estimate used for the Horizon Europe project "Biodiversity Digital Twin for Advanced Modelling, Simulation and Prediction Capabilities" (https://biodt.eu/).
author [?]	Christoph Wohner
contentSize [?]	3.9 MB
identifier [?]	https://doi.org/10.23728/b2share.57315b8581cf45f6a5686b8ec1e0a788
profile	https://github.com/BioDT/biodt-fair/discussions/8
license [?]	AT_Schrankogel_license.csv
dateCreated [?]	2024-02-20
keywords [?]	• BioDT • Grassland pDT
url [?]	https://doi.org/10.23728/b2share.57315b8581cf45f6a5686b8ec1e0a788
variableMeasured [?]	Species cover
measurementTechnique [?]	AT_Schrankogel_license.csv
spatialCoverage [?]	GLORIA Master Site Schrankogel (AT-SCH), Stubaier Alpen - Austria
temporalCoverage [?]	• 1994 • 2004 • 2014
version [?]	1
publisher [?]	Long Term Ecological Research Network
hasPart [?]	• AT_Schrankogel_data_cover.csv • AT_Schrankogel_license.csv • AT_Schrankogel_method.csv • AT_Schrankogel_reference.csv

Cultural Ecosystem Services pDT - Biodiversity Model

Download all the metadata for Cultural Ecosystem Services pDT - Biodiversity Model in JSON-LD format

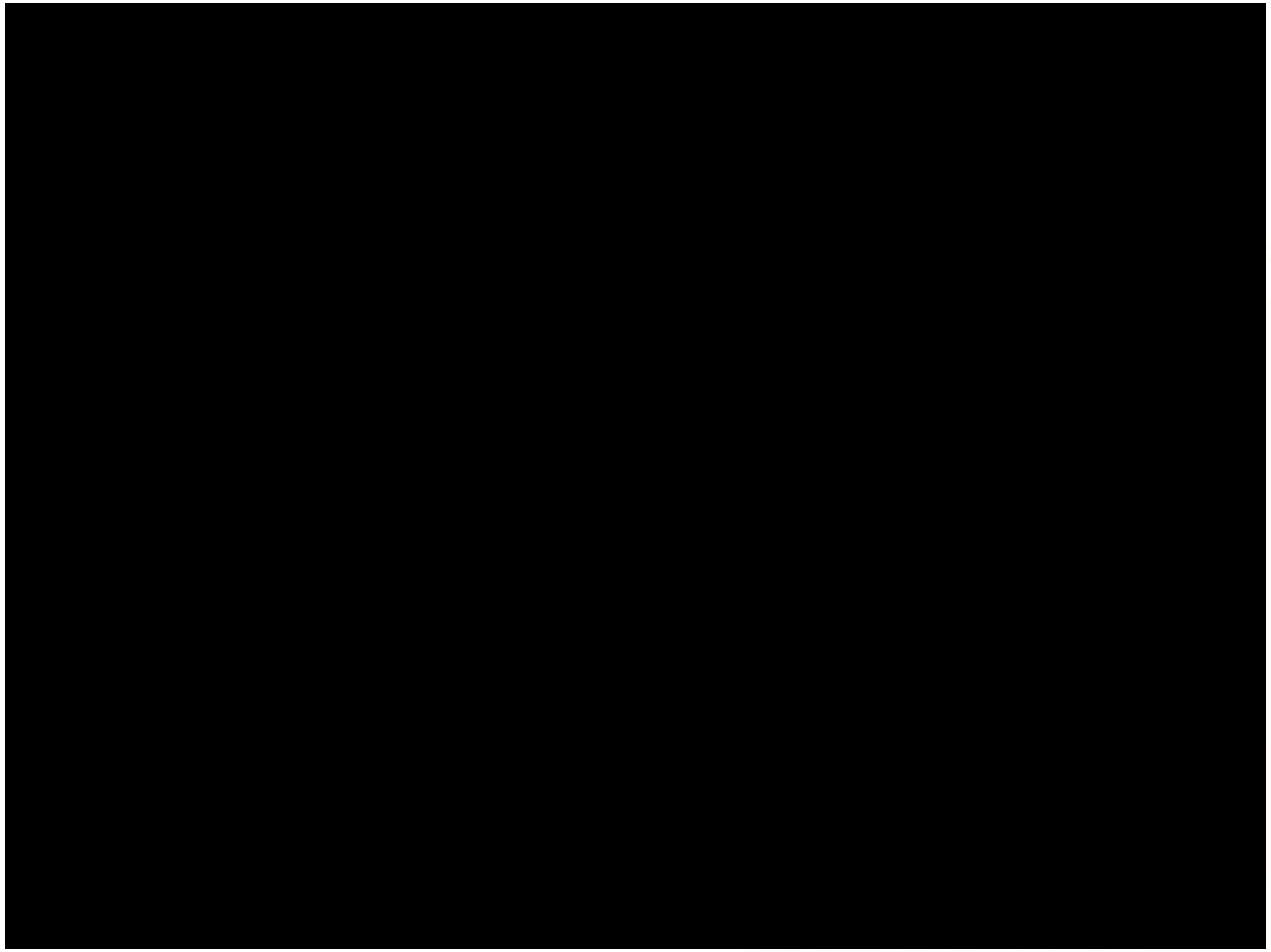
Check this crate

Go to: Species occurrence data from the Cairngorms, Scotland

@id	https://doi.org/10.15468/dl.b3n3r9
name	Species occurrence data from the Cairngorms, Scotland
@type	DataFeed
description	Species occurrence data from the Cairngorms, Scotland was obtained by download from GBIF. We filtered environmental variables to only include environment data from within a 5 km buffer of recorded occurrences, and conducted spatial thinning.
encodingFormat	
contentSize	179 KB
variableMeasured	species occurrence
measurementTechnique	
spatialCoverage	Cairngorms National Park
temporalCoverage	
version	
publisher	GBIF
	Items that reference this one
supportingData	Cultural Ecosystem Services pDT - Biodiversity Model

agroclim workflow demo

agroclim - using crop growth models and DestinE data

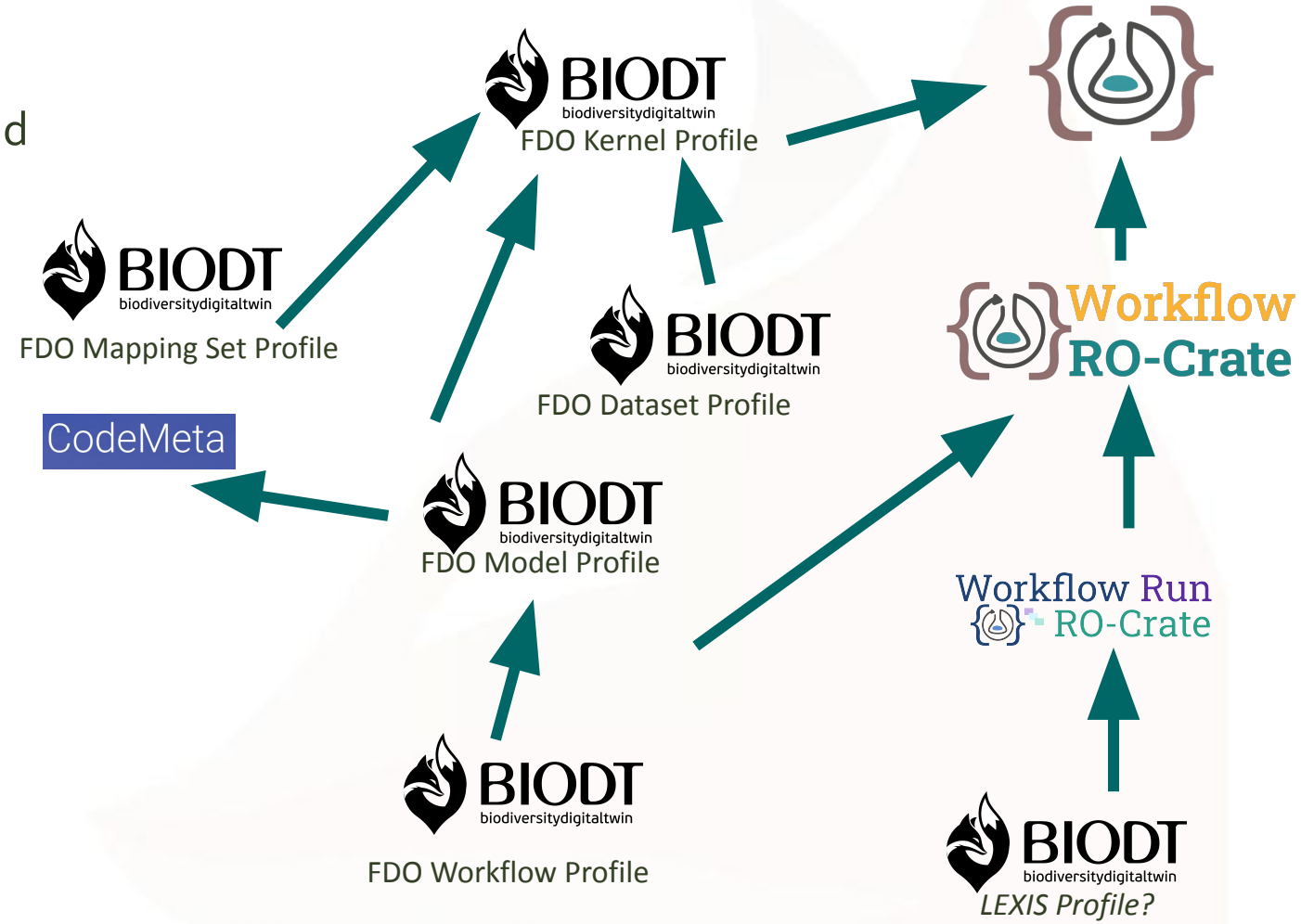


https://bit.ly/agroclimmov

RO-Crate Profiles: Defined Content Checklists

Profiles give a set of conventions, types and properties that minimally require and expect to be present in that subset of RO-Crates.

- **Duck typing** for creation, consumption, rendering
- **Classification** for finding and comprehension.
- [Profile Crate](#) for further defining RO-Crates profile resources
- Key to **extensibility and diversity**



Julian Lopez Gordillo
https://github.com/BioDT/biodt-fair

BIODT
biodiversitydigitaltwin

RO-Crate tutorials & tools

https://www.researchobject.org/ro-crate/tutorials

Sandbox (experimental): https://ro-crate.ldaca.edu.au/

Crate-O editor: https://language-research-technology.github.io/crat

Python: https://pypi.org/project/rocrate/

Schedule

	Setup	Download files required for the lesson
00:00	1. Introduction	How do I package data in a FAIR way? How can I list the authors of individual files? Can I use multiple licenses in the same data package? How can I visualize JSON-LD metadata?
00:17	2. Turning a folder into an RO-Crate	How can I start a new RO-Crate?
00:24	3. Making a metadata descriptor	Which RO-Crate version is used? How can the crate self-identify as an RO-Crate?
00:28	4. Declaring the root folder	What is the root folder?
00:31	5. Describing the root entity	How can I describe the crate? How do I specify the license of the RO-Crate?
00:39	6. Adding cross-references	How can I describe an entity further? How can I cross-reference different entities?
00:46	7. Data entities	How do I describe the files in my RO-Crate?
00:50	8. Contextual entities	How can I describe things in the world? How can I give details about licenses?
00:54	9. Authorship in crates	How can I list who made the content of the crate? How do I affiliate a person with their place of work?
01:00	10. Validating JSON-LD	How can I validate the JSON-LD?

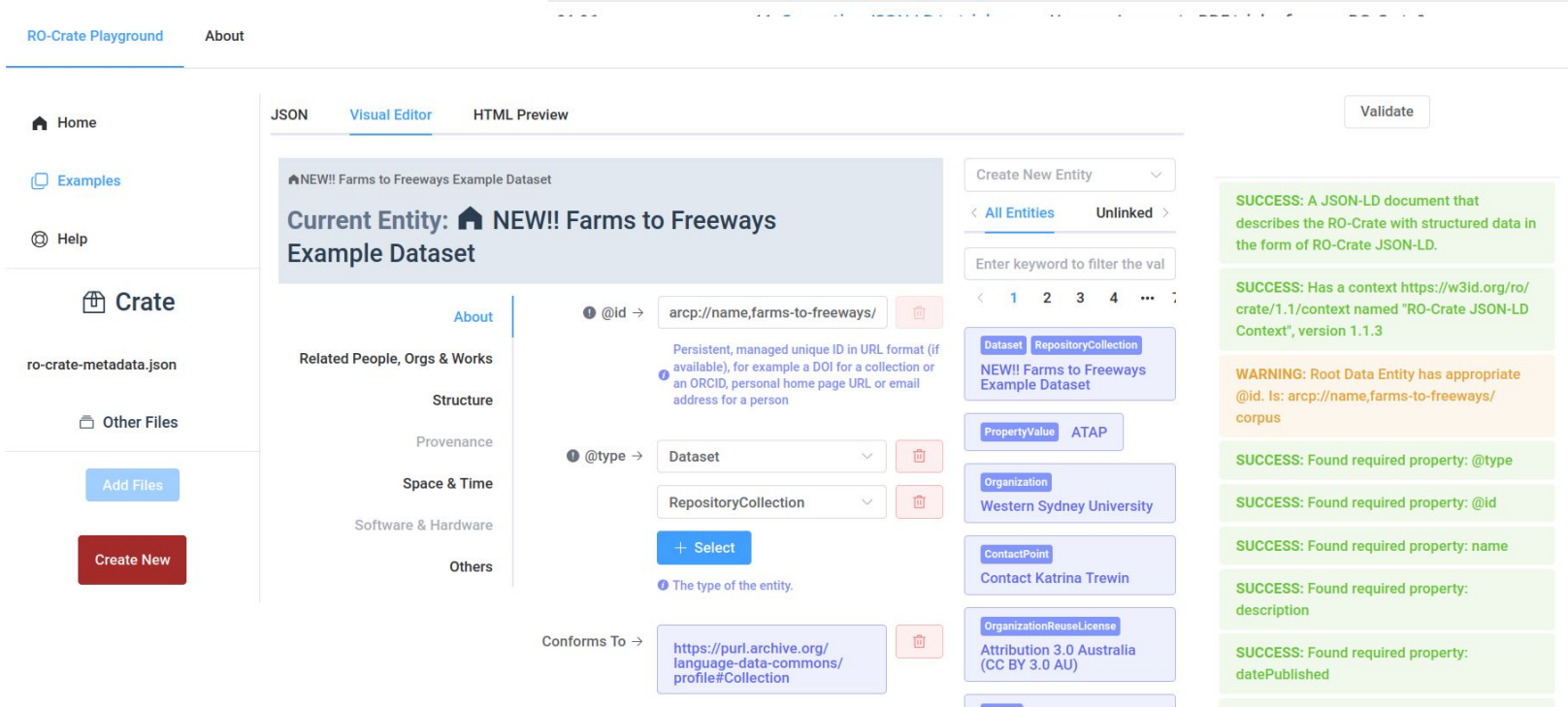
Creating an RO-Crate

In its simplest form, an RO-Crate is a directory tree with an `ro-crate-metadata.json` file at the top level that contains metadata about the other files and directories, represented by data entities. These metadata consist both of properties of the data entities themselves and of other, non-digital entities called contextual entities (representing, e.g., a person or an organization).

Suppose Alice and Bob worked on a research task together, which resulted in a manuscript written by both; additionally, Alice prepared a spreadsheet containing the experimental data, which Bob used to generate a diagram. Let's make an RO-Crate to package all this:

```
from rocrate.rocrate import ROCrate

crate = ROCrate()
paper = crate.add_file("exp/paper.pdf", properties={
    "name": "manuscript",
    "encodingFormat": "application/pdf"
})
table = crate.add_file("exp/results.csv", properties={
    "name": "experimental data",
    "encodingFormat": "text/csv"
})
diagram = crate.add_file("exp/diagram.svg", dest_path="images/figure.svg", properties={
    "name": "bar chart",
    "encodingFormat": "image/svg+xml"
})
```



Current RO-Crate trends in biodiversity & earth sciences

RO-Crate and Signposting "Webby FDOs" is recognized as a viable **FAIR Digital Objects** implementation (FDO2024)

Biodiversity Genomics Europe using RO-Crate for ENA submissions

Dataverse has added RO-Crate support

RO-Crate in **climate science**: FAIR-EASE, CLIMATE-ADAPT4EOSC, FAIR2ADAPT

Digital Twin for GEOphysical extremes (**DT-GEO**): RO-Crate both for HPC workflows (COMPSs) and in EPOS Metadata schema

https://www.researchobject.org/ro-crate/community

Next steps (a taster!)

EuroScienceGateway: Workflows as FAIR Digital Objects in EOSC

EOSC-ENTRUST, **EVERSE** and **HDR UK** using RO-Crate for federated analytics "Five Safes RO-Crate"

BioFAIR UK: BioCommons infrastructure for UK life science researchers

NFDI4DS: Hackathon 2024: Webby FDOs with RO-Crates and FAIR Signposting

RO-Crate **governance**: Community driven (2018→)

→ Steering committee (2025)

Minutes/agenda

2024-10-24 Research Object Crate #98

2024-10-10 Research Object Crate #97 (EOSC)

2024-09-26 Research Object Crate #96

2024-09-12 Research Object Crate #95 (EOSC/governance)

https://www.researchobject.org/ro-crate/community

Recent publications

Otso Ovaskainen, et al. (2024): **Prototype Biodiversity Digital Twin: Real-time bird monitoring with citizen-science data**. *Research Ideas and Outcomes* 10:e125523 https://doi.org/10.3897/rio.10.e125523

Simon Rolph, et al. (2024): **Prototype Digital Twin: Recreation and biodiversity cultural ecosystem services.** *Research Ideas and Outcomes* 10:e125450 https://doi.org/10.3897/rio.10.e125450

Desalegn Chala, et al. (2024): **Prototype biodiversity digital twin: crop wild relatives genetic resources for food security**. *Research Ideas and Outcomes* 10:e125192 https://doi.org/10.3897/rio.10.e125192

Jonas Grieb, et al. (2024): **Using Webby FDOs to Integrate AI Taxon Identification and Citizen Science**. *Biodiversity Information Science and Standards* 8:e134757 https://doi.org/10.3897/biss.8.134757

Claus Weiland, et al. (2024): **Dataspace Integration for Agrobiodiversity Digital Twins with RO-Crate**. *Biodiversity Information Science and Standards* 8:e134479 https://doi.org/10.3897/biss.8.134479

Tomáš Martinovič, et al. (2024): **Graphical User Interface for Biodiversity Digital Twins**: Data Challenges. Biodiversity Information Science and Standards 8:e135092 https://doi.org/10.3897/biss.8.135092

Sharif Islam, et al. (2024): **Bridging Data Standards and FAIR Principles in Biodiversity Digital Twinning: Prototyping, Challenges, Lessons Learned, and Future Plans**. *Biodiversity Information Science and Standards* 8:133089 https://doi.org/10.3897/biss.8.133089

Rafael Ferreira da Silva, et al. (2024): **Workflows Community Summit 2024**: Future Trends and Challenges in Scientific Workflows. https://doi.org/10.5281/zenodo.13844759

Ove Johan Ragnar Gustafsson, et al. (2024): **WorkflowHub: a registry for computational workflows**. *arXiv*:2410.06941 [cs.DL] https://doi.org/10.48550/arXiv.2410.06941

Sean Wilkinson, et al. (2024): **Applying the FAIR Principles to Computational Workflows**. *arXiv* 2410.03490 [cs.DL] https://doi.org/10.48550/arXiv.2410.03490

Simone Leo, et al. (2024): **Recording provenance of workflow runs with RO-Crate**. *PLOS One* **19**(9):e0309210 https://doi.org/10.1371/journal.pone.0309210

Stian Soiland-Reyes, et al. (2024): **Practical webby FDOs with RO-Crate and FAIR Signposting**: Experiences and lessons learned. International FAIR Digital Objects Implementation Summit 2024 (FDOF 2024). https://s11.no/2024/webby-fdos/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