Morphological restoration of temporary watercourses in the National Forest of Chaux

Year of issue

2025

Summary

Chaux Forest is a timber production area threaded by many small, originally sinuous headwater streams. A 2006–2008 LIFE pilot restored two intermittent tributaries; building on those results, the National Forest Office (ONF) scaled up to ~45 km of temporary tributaries from 2015, redirecting flows to former meanders, adding coarse woody material and sediment to counter decades of straightening/drainage that had widened and incised channels, sped floods and lowered near-surface water tables. Since 2021, ONF and the Doubs-Loue river syndicate have restored ~13 km of the Clauge mainstem inside the forest (2021–2023): narrowing/raising the bed with vegetated berms, gravel recharge, selective infilling of over-wide sections and engineered log structures. Monitoring reports a strong hydrological response: depending on context, the hydropériode of the Clauge headwaters and intermittent tributaries now increases by ~2–6 months per year (including +3–12 weeks in spring), alongside recovery of aquatic bio-indicators. In June 2025 the project received the national “Rivière en bon état” distinction and the Nature-based Solutions award from the Rhône-Méditerranée-Corse Water Agency. Next step: design for restoring the Tanche tributary, with works targeted for 2026.

Photo Gallery



Location

47.0813, 5.6601

Project

NWRM

National ID

France_13

Sector

Hydromorphology

Installation Date

2009-2025

Implementation status

Completed

Overview

Location of the project

The Chaux forest is covered by a large number of small streams, originally winding and of small size (more than 400 km). They are located at the head of the catchment area and are tributaries of the Clauge.

Country

France

NUTS2 Code

Franche-Comté

Sponge measures implemented in the case study

Restoration and reconnection of seasonal streams

Coarse woody debris

Re-meandering

Wetland restoration and management

Water sensitive forest management

Objectives

• Restore hydrologic function of the Chaux headwaters and mainstem (≈45 km tributaries; ≈12 km mainstem).
• Reconnect wet valley fringes and floodplain (reported several hundred hectares reconnected).
• Raise water table / lengthen hydroperiod; reduce incision/erosion; recover biodiversity (fish, macroinvertebrates, amphibians).

Involved partners

Authority type	Authority name	Authority role	Comments	Authority responsibility
Other	National office of forest (ONF)	Initiation of the measure	Project owner, the forest manager for both the french state and the local authorities owning the land.	Responsible
Research institute / University	Marie and Louis Pasteur University - Sciences and technologies department	Monitoring	—	Supporting
Local water authority	SMIX Doubs Loue	Implementation	Local authority responsible for aquatic environment management and flood prevention	Responsible
Architects / Engineers	Teleos	Determination of design details of the measure	Modeling of the project	Supporting

Documents

mnre_rex08_foret_de_chaux.pdf (1.38 MB)

Site Information

Climate Zone

Cool temperate moist

Temperature (°C)

11.60 °C

Elevation range

260 m

Slope range

0-1%

Groundwater level

An impermeable clay layer is only 7 meters deep. The maximal water storage volume in the soil is easily reached after rain.

Vegetation class

Oak–beech high forest (with hornbeam), large lowland deciduous massif.

WFD Ecological status

Good

WFD Chemical status

Good

Water quality status

No major water quality issues observed. Roads, forestry and hunting activities could cause some pollution events though.

Design and Implementation

Project scale

Meso

Project scale specifications

Work carried out on approximately 60 km of temporary tributaries of the Clauge River (until 2018), and more for the Tanche river (2025).

Project area

2 700 ha

Project area specifications

Restored watercourse represents about 60 km, out of the estimated 450km of watercourses in the whole forest.

Size

60.00

Size unit

km

Principles

Community involvement, with pedagogic explainations.
Integrating a relfexion on waterways crossing and creation of bypass paths where possible.
Use of LIDAR technology when possible to identify the former river beds.

Factor constraints

Low-gradient, alluvial/lacustrine valley floors (ancient Rhine deposits, “lac Bressan” context) with hydromorphic, fine soils; shallow water table; dense legacy drainage/straightening; extensive forest road network. Constraints: Natura 2000 and Water Law permitting windows; soil bearing capacity and machinery impacts. Favourable: public ownership/ONF stewardship, local wood/sediment availability, clear LiDAR-visible paleo-meanders.

Favourable preconditions

Almost all the temporary tributaries of the Clauge being originally meandriformes, a remeandering operation is justified following their transformation in the 1960s into deep rectilinear ditches, so that they can regain a hydrological functioning that allows them to support an associated biodiversity.

Financing

Total cost

1429000.00 €

Total cost information

• 2015–2019 (headwater tributaries, ~45 km): €581,500 total. Funding: €465,200 Agence de l’eau RMC; €116,300 ONF self-financing. Tranche costs: T1 €263,500; T2 €198,000; T3 €120,000.
OIEau
• 2021–2023 (mainstem Clauge, ~12–13 km): €848,000 (excl. VAT). Funding: €594,000 (70%) Agence de l’eau RMC; remaining 30% by project owners/partners.

Financing authorities

Authority name	Type of funding	Financing share
Water Agency Rhône Méditerranée Corse	Sub-national funds	70%
National Forest Office (ONF)	National funds	30 %

Compensations

No

Policy and Governance

Policy description

The Chaux forest is covered by a large number of small streams, originally winding and of small size (more than 400 km). All the temporary tributaries of the Clauge were transformed in the 1960s into deep straight ditches via canalization works. ONF led early phases (post-LIFE 2008 pilots) with Univ. of Franche-Comté; since 2018 the Syndicat Mixte Doubs-Loue (SMIX) shares/co-leads under GEMAPI for mainstem works; Agence de l’eau RMC is principal funder. The measure targets WFD ecological status via hydromorphological recovery, mitigating historical drainage/channelization and climate-driven drought stress in a Natura 2000 forest.

Land ownership

State-owned: the Forêt domaniale de Chaux belongs to the French State; land is managed by ONF (project owner).

Target remarks

Significantly restoring the hydraulic functioning of the Clauge and improving the conservation status of the species covered by the Habitats Directive.

Requirement directive

Requirement directive	Specification
Other EU	Habitats Directive

Requirement directive remarks

Emblematic species to be preserved in a Natura 2000 zone.

Part of a wider plan

No

Public consultation

Yes

Consultation activities

Activity stage	Activity type	Key issues	Comments
Design phase	Consultation meetings	Preconcieved ideas from local residents, representatives, hunters, etc. : "The project will flood the forest", "The Clauge floods will be worsen".	The goal was to explain how the various preconcieved ideas were wrong.

Activity stage	Activity type	Key issues	Comments
Implementation phase	Conference with officials and local representatives (2018)	The budget allowed to the project was considered by some as too expensive, especially in comparison with the smaller budget allowed for forest roads or other infrastructures.	Explaining the project and how it works.
Implementation phase	Press articles	—	A significant effort was made to communicate informations to the local press.
Other	Information panels on a new wooden footbridge over the river downstream (2025).	—	The goal is to communicate with people directly on the field.

Has contractual arrangements

No

Impacts and Monitoring

Monitoring System

Monitoring parameters

A monitoring protocol was set up in 2017 with the University of Franche-Comté (technical assistant) and the ONF (National Office of Forest), with the help of 2 master trainees.
Entomological monitoring is carried out in the spring, at the net and in the watercourses and is led by the University. It is carried out before and after, at a control site, and at restored sites, with a time grid every two and three years. The control shows that the observed changes are not due to climatic variations.
Piezometric monitoring (individual or online). : About twenty piezometers have been installed with weekly automatic readings.
Dendrometric monitoring : At the level of the piezometers, vegetation monitoring plots are placed by the ONF (height, diameter, health status, dominance) on control plots of 1000m². The population evolution will be monitored over the long term.
2 weather stations will be installed in 2025 to study pluviometry and nebulosity.

Maintenance

Maintenance requirements

Almost no maintenance operations, the idea is to let ecosystems repair themselves. Some small operations can be carried out shortly after installation (removing unwanted debris for example).

Impact Assessment Methodology

Biophysical impact assessment method

Comparison with a control site.

Socio-economic Impacts

Direct benefits

Social benefits are limited, as the forest is not a huge tourism area.
Economic benefits mainly come from the provided peak-flow reduction downstream.

Biophysical impacts: Hydrology

Hydrological effects

The increase in low-flow rates and the extension of the hydroperiod of the temporary streams, as well as the peak-flow reduction downstream..

Information on retained water

Hydroperiod increase +2–6 months/year (incl. +3–12 spring weeks) in restored reaches; water table residence time increased.
Restored channel complexity (sinuosity, benches, large wood), floodplain reconnection (hundreds of ha), and attenuation of downstream flood effects during high water.

Information on increased groundwater level

Piezometric monitoring shows an increase in the hydroperiod (+20 days) because the time of presence of water in the watercourse is longer, as these are surface aquifers that are in silts and dry in summer, water is more available for trees in spring. When the time of presence of water in the stream is extended, it is also extended in the groundwater table.

Information on Restoring hydraulic connection

The hydrosystems improved as wanted. Waterways are balancing themselves on the way to complete restoration.

Biophysical impacts: Biodiversity

Improved biodiversity

Yes

Information on improved biodiversity

Biodiversity monitoring reveals a better attractiveness of the spawning sites for amphibians (frogs, salamander, newt, reproduction multiplied by 10) and amphibians because the river was not initially biogenic;
It also reveals an improvement in habitat for entomofauna, with the number of taxa multiplied by 2, a recovery by ephemeropterans, perlids and trichopterans protected at the European level (e. g. Hagenella clathrata classified as endangered (EN) on the IUCN Red List). There is also an improvement in quality (i.e. more demanding species that are dependent on wetlands).

Biophysical impacts: Others

Information on ecosystem impact climate regulation

Climatic impacts will be assessed using data from the weather station installed in 2025. Positive impacts (heat reduction) due to nebulosity improvements are expected.

Lessons Learned

Key lessons

As of 2025, the morphological restoration is considered a success. The restoration was awarded a "Nature Based Solution Price" in 2025 by the French ministry of environment.
Anticipation is needed to carry out a similar project. It allows to prevent future problems, human or technical.
It is better to use the available technologies (LIDAR, modeling) for design and communication.
The sponge effect is working, but is not perfect : the massive october 6 2024 flash flood showed how even with fucntioning sponge measures flood can cause catastrophes.

Barriers

Barrier type	Barrier role	Comments
Legal obligations / restrictions	Main barrier	The main constraint was the completion of the public inquiry, since it represents a significant cost, and also a duration of 6 to 8 months.
Attitude of relevant stakeholders	Secondary barrier	There was a need to negotiate with people, to explain to them the necessity of the chosen measures in relation to the local hydrology and geology.

Drivers

Driver type	Driver role	Comments
Other	Main driver	The fact the habitat was seriously degraded and other experience of successful restoration of habitat on a similar area was a key driver, as positive results were already forecasted from the beginning.

Success factors

Success factor type	Success factor role	Comments
Other	Main factor	The presence of only one forest manager over a large area. Many differetn land woners and managers would have slowed down and/or prevented a similar project to be implemented.
Available support tools	Main factor	The access to LIDAR technology to identify the various former river beds helped to restore them.
Available support tools	Main factor	The modelisation work carried out by TELEOS allowed to show the local community how this project worked.

Cost effectiveness

The project was a compromise between the most effective (filling of all straightened river beds) and least expensive (leaving ecosystem heal by themselves), choosen to be the most cost effective.

Transferability

Highly transferable to low-gradient forested headwaters where legacy drainage/straightening dominates. Critical enablers: public land control; integrate works with forest operations to minimize new crossings; use local materials; LiDAR-guided design; secure Water Law/Natura 2000 permits and work within seasonal windows; plan multi-year adaptive monitoring.

Sources

Sources

Reconstitution des écoulements de surface de deux affluents temporaires de la Clauge amont

Dossier de demande d’autorisation au titre de la Loi sur l’Eau et les Milieux Aquatique et de Natura 2000

En forêt de Chaux, la restauration des cours d’eau porte ses fruits

Reviviscence des affluents de la Clauge