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# A WAR ON SEDIMENT ? UNDERSTANDING AND GOVERNING SOLID TRANSPORT IN THE RHÔNE WATERSHED (1840-1920)

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## INTRODUCTION

In 1978, a sediment flushing of the Génissiat dam was blamed for a massive fish die-off in the Rhône. The resulting mobilisation encouraged the CNR, the manager of the Rhône dams, to revise its flushing methods and take into account the impact of sediment on fauna. In many respects, the 1978 "great flush" marked the emergence of new concerns for the ecological "health" of the river and of political movements targeting sediment management. Nevertheless, the links between socio-political configurations, sediment knowledge and technical management are not original to the late 20th century. **Sediments in the Rhône have been at the heart of technical, cognitive and political processes involved in river development for at least two centuries.**

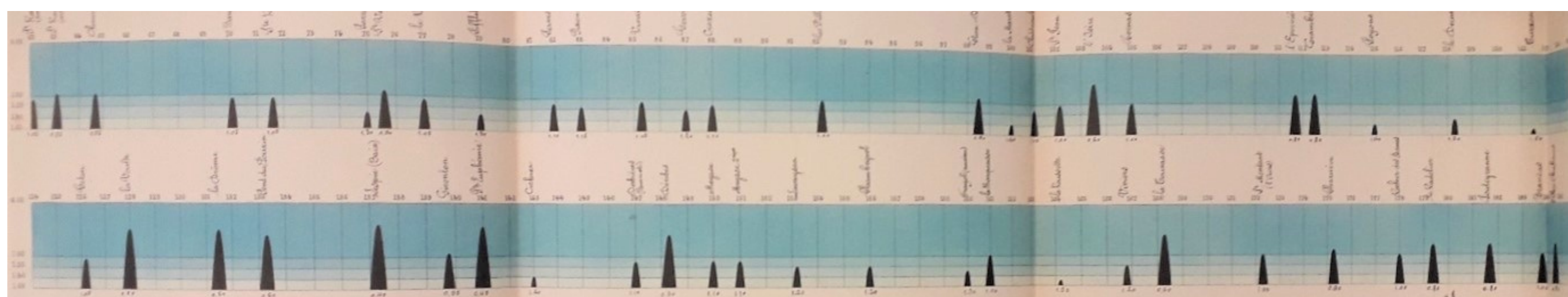
## SEDIMENTS IN HISTORY

In the 19th century, **Ponts et Chaussées engineers and foresters** were the principal mediators of the relationship between river and society. To study how sediments were understood and managed we have thus examined **records of engineers and foresters** in charge of the Rhône basin management at the **National Archives** (serie F) and at the **Archives départementales du Rhône** (serie S), the main **treatises of river management** in the 19th century, and the **entire collection of journals** of these corps: *Annales des Ponts et Chaussées* (1833-1940), *Annales forestières* (1842-1865), *Revue des Eaux et Forêts* (1862-1940), *Génie Civil* (1880-1940), and *Houille Blanche* (1902-1940).

These sources reveal two opposite understandings of sediments. For agriculture, sediments were a valuable agent of plant nutrition. For river development projects they were an obstacle to water flows. We have found that this **negative understanding of sediments became dominant** in river management and justified ambitious forms of control of sediment production and circulation.

## CLEARING A WATERWAY

At the turn of the 19th century, French authorities hoped to transform the Rhône into a major waterway. The river, however, was unsuitable for steam navigation and companies demanded a clear and deeper channel. In 1836, the state established the **Rhône Special Service** (Service spécial du Rhône) to improve navigability by controlling solid transport. Over the decades, the Special Service perfected **methods to deepen the river by narrowing its channel and flushing out the sediments**. The chart below, produced in 1892, visualizes the results, graphically representing the opposition between clear water (blue), a vector of transport, and sediments (dark), a nuisance to eliminate.



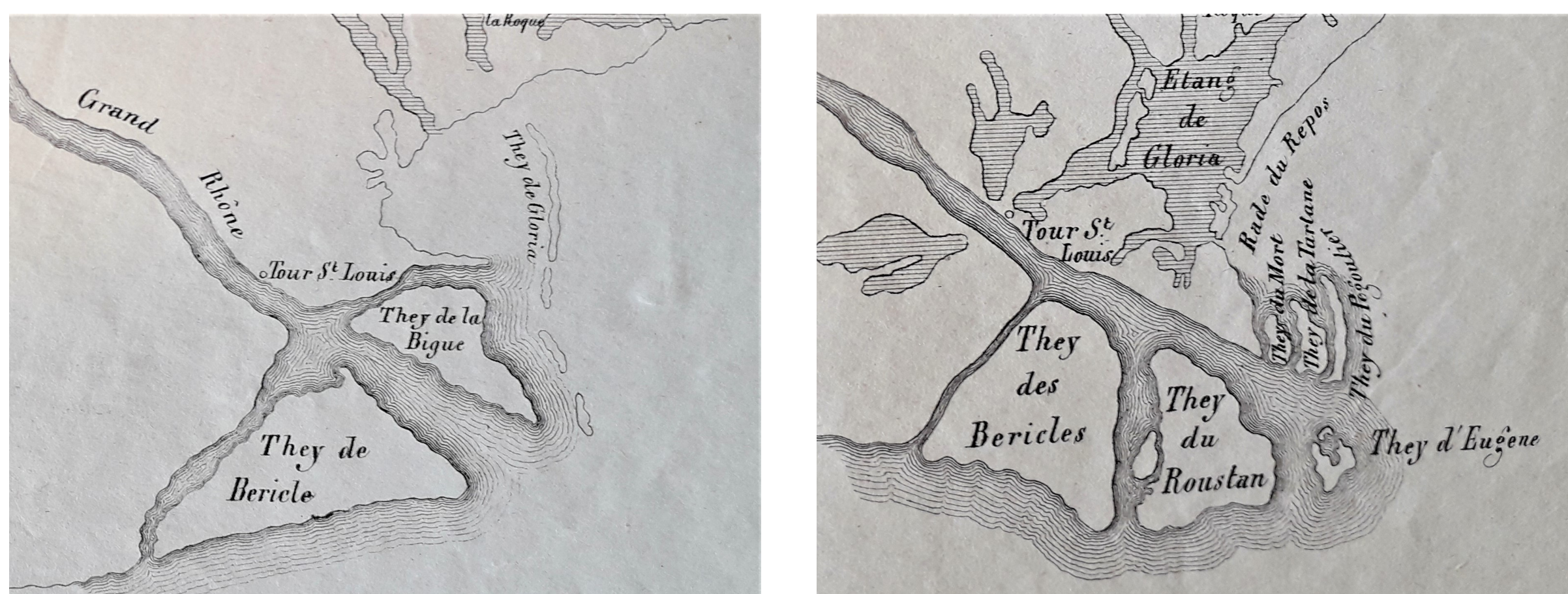
Graphic representation of the Rhône shoals before the 1878 works, attached to the general report on the situation of the Special Service in 1892, Archives départementales du Rhône, S/3243.

Sedimentary congestion was particularly problematic at the river mouths. The challenge of sedimentary deposits that extended the delta and clogged the waterway led to the **first experiments to estimate solid transport and the rate of deposition** and sea filling by the sediments of the Rhône. In 1749, engineer Bernard Forrest de Bélidor estimated the rate of progradation of the Rhône delta at over 100 meters per year. A century later, Alexandre Surell estimated anew the rate of progradation and envisioned to improve the mouths by narrowing the main channel and concentrating the flow.

Avancement en mer (kilomètres)	Volume des dépôts en millions de mètres cubes	Temps du dépôt (ans)	Marche annuelle (mètres)
2	191 65	11,27	177
4	738 83	43,46	62
6	1,836 01	108	31
8	3,666 55	215 67	18,60

Table summarizing the estimation of the future growth of the Rhône delta, from A. Surell, Mémoire sur l'amélioration des embouchures du Rhône, 1847.

The congestion of the delta also gave rise to **programs of mountain soil management**. In 1797, engineer Jean-Antoine Fabre proposed to intensively reforest the Alps in order to limit the deposits in the Rhône delta, which "can only come from the debris of the mountains" (1). Trees, by limiting erosion, would make it possible to moderate sediment production and thus, to reduce the deleterious deposition that clogs the delta. This is one of the first expressions of an explicit desire to control solid transport via reforestation at the scale of the watershed.



Maps of the Rhône delta in 1760 (left) and in 1842 (right) showing the significant growth undergone by the mouths. Archives nationales, F/14/6541.

1) Jean-Antoine Fabre, *Essai sur la théorie des torrents et des rivières*, Paris, Bidault, 1797.  
 2) « Discours de S. M. l'Empereur », *Le Moniteur universel*, 16/02/1857.  
 3) Robert Walther, "Note sur l'engravement et le dégravement d'un bassin d'accumulation. Histoire du lac du Motty", *Revue de Géographie Alpine*, vol. 24, n° 2, 1936, p. 315-328.  
 4) Félix Drouhet, "Le charriage des alluvions par les cours d'eau", *Le Génie civil*, vol. 68, n° 24, 1916, p. 378-383.  
 5) M. Widmann, "Barrages hydro-électriques et érosion des terrains en montagne", *Revue forestière française*, 1951, p. 640-646.  
 For more informations about sediment management and government, see Titouan Souquet, "Au-delà de l'eau. Le 'souti sédimentaire' dans l'aménagement du bassin du Rhône (1835-1940)", master thesis, Sciences Po Paris, 2022.

## CURBING SEDIMENT PRODUCTION

By the mid 19th century, flood control rose to preeminence in river management alongside navigation. In 1840 and 1856, the main rivers of France flooded. The Rhône valley was particularly damaged. In this context, both the public opinion and the government demanded a management scheme that could prevent floods altogether, fulfilling Napoleon III promise that "rivers, like the revolution, return to their beds, and can no longer leave them" (2).

The program of sediment reduction drafted by Fabre found an audience with Alexandre Surell's 1841 book *Etude sur les torrents des Hautes-Alpes*. Surell argued that soil erosion upstream and deposition downstream generated hydrological and geomorphological instability in the Rhône River. Reforestation in the Alps was thus a necessary condition to the domestication of the watershed.



Representation of a torrent watershed in the *Etude sur les torrents des Hautes-Alpes* (2nd Ed. 1870).

It was not an entirely new idea but found an echo in a context of disastrous floods. By the mid-century, repeated flooding was blamed on sedimentary congestion and riverbed aggradation. Curbing sediment production with forests promised to solve flooding at the roots.

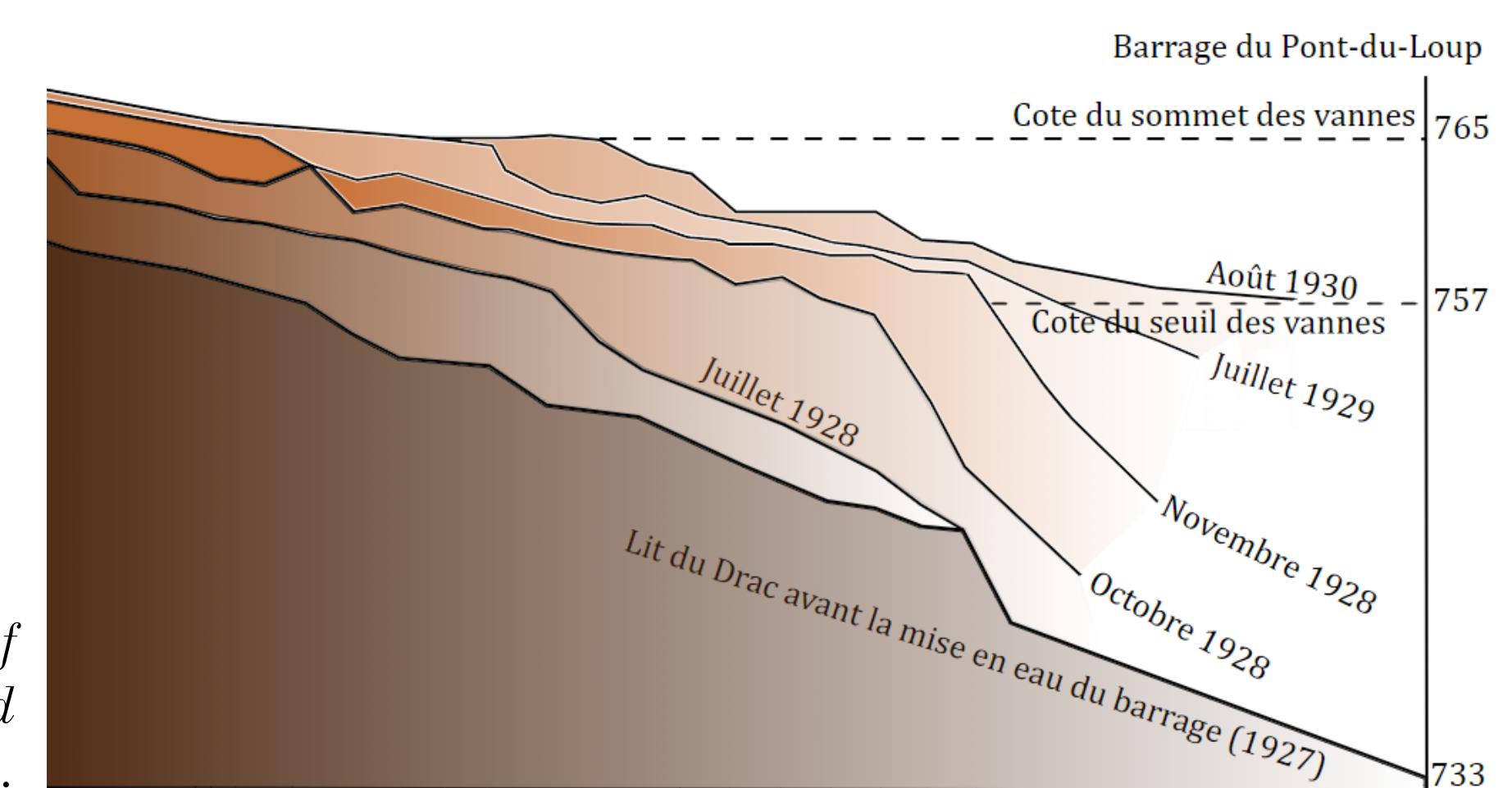
Surell's book had a long-lasting influence. In its wake, curbing sediment production through massive **upland reforestation became a core principle of river management**. This principle was at the hearth of the French forest law of 1860, which launched a broad **reforestation programme aimed at sediment reduction**.

## SEDIMENTS AND HYDROELECTRICITY

The translation of Surell's theories into practice was contested. Local communities often opposed reforestation programs and the state had to revise its reforestation ambitions in 1864 and 1882. Faced with resistance, foresters were eager to reassert the virtues of sediment scarcity, to compensate their lack of authority on mountain territories. At the turn of the twentieth century, the emergence of hydroelectricity in the Alps, quickly nicknamed "white coal" (*houille blanche*) gave to the forest administration a new tool to increase the legitimacy of its craft.

"White coal" industrialists feared sediment. **Sand and gravel could quickly fill up reservoirs**, thus rendering them useless. The graph on the right depicts the rapid filling of the 1920s Pont-du-Loup reservoir, almost entirely clogged after only three years.

Graphic representation of the filling of the Pont-du-Loup reservoir, adapted by the authors from R. Walther (3).



### LA HOUILLE BLANCHE ET LA QUESTION SYLVO-PASTORALE

Conférence faite aux élèves de l'Institut Electrotechnique de Grenoble, par notre collaborateur, le Commandant AUDEBRAND, sous les auspices de la Société pour le développement de l'Enseignement technique près l'Université de Grenoble.

#### REBOISEMENT

##### LA PREMIÈRE ÉTAPE DE L'ASSOCIATION CENTRALE POUR L'AMÉNAGEMENT DES MONTAGNES

La Chambre des Députés, en votant le 13 mars 1909 la loi libérale pour favoriser le reboisement et la conservation des forêts privées, dont l'Association Centrale pour l'Aménagement des Montagnes avait pris l'initiative, a encouragé les BOISEMENTS, IRRIGATIONS BARRAGES-RÉSERSOIRS (1)

#### BOISEMENTS, IRRIGATIONS BARRAGES-RÉSERSOIRS (1)

Les questions d'intérêt immédiat appartenant au domaine actuel des Sciences et de l'Industrie ne doivent pas à ce point fixer notre attention que nous ne puissions jamais la porter sur les grands problèmes dont la solution s'imposera aux ingénieurs qui nous suivront.

To calculate the lifespan of projected dams new research emerged that **mathematized the growth of sedimentary deposits**, particularly on the tributaries of the Durance or at Génissiat, on the Upper Rhône (*Haut-Rhône*) (4).

The foresters program of curbing sediment production had a new appeal in this context, as apparent in publications such as *La Houille Blanche*, the main venue of the hydroelectric industry. From 1900 to 1920, it served as a forum for foresters who ardently defended reforestation to prevent reservoirs sedimentation (see image on the left).

Headlines linking reforestation, sediment control and hydroelectric development in the 1900s.

From the 1920s onwards, technological changes and the decline of the scholarly authority of Surell's theories reduced the appeal of the foresters program for hydroelectricity. However, sediment control did not disappear from view. Armand, a Ponts et Chaussées engineer in charge of energy development in the Rhône, pointed out in 1918 what he saw as a happy corollary of Alpine dams. **Once all tributaries of the Rhône were dammed, sediment discharge would be considerably reduced in the river channel itself, which would facilitate river development.**

The above remarks prove that Alpine hydroelectric development was coupled with a struggle, if not declared, at least implicit, **to clarify the waters of the Rhône**. Moreover, mountain restoration continued to be pursued throughout the 20th century and curbing sediment production remained a declared goal. In 1951, Windmann, an Eaux et Forêts officer, was still arguing that trees protected dams by preventing the erosion of mountainous soils and therefore, in the end, reservoirs sedimentation (5). The war on sediment was now an axiom.