Environment & Society Portal

The White Horse Press

Full citation: Crook, D.S. D.J. Siddle, R.T. Jones, J.A. Dearing, G.C. Foster and R. Thompson. "Forestry and Flooding in the Annecy Petit Lac Catchment, Haute-Savoie 1730–2000." *Environment and History* 8, no. 4 (November 2002): 403–28. http://www.environmentandsociety.org/node/3135.

Rights: All rights reserved. © The White Horse Press 2002. Except for the quotation of short passages for the purpose of criticism or review, no part of this article may be reprinted or reproduced or utilised in any form or by any electronic, mechanical or other means, including photocopying or recording, or in any information storage or retrieval system, without permission from the publishers. For further information please see http://www.whpress.co.uk.

Forestry and Flooding in the Annecy Petit Lac Catchment, Haute-Savoie 1730–2000

D.S. CROOK*, D.J. SIDDLE, R.T. JONES, J.A. DEARING, G.C.FOSTER

Department of Geography
University of Liverpool
Liverpool L69 7ZT, UK

R. THOMPSON

Department of Geology and Geophysics
University of Edinburgh
Edinburgh, UK

**Corresponding author. Email: dcrook@liv.ac.uk*

ABSTRACT

Upland environments are particularly vulnerable to the stresses of climate change. The strength and persistence of such forces are not easy to measure and hence comparison of climate impacts with anthropogenic impacts has remained problematic. This paper attempts to demonstrate the nature of human impact on forest cover and flooding in the Annecy Petit Lac Catchment in pre-Alpine Haute Savoie, France, between 1730 and 2000. Local documentary sources and a pollen record provided a detailed history of forest cover and management, making it possible to plot changes in forest cover against local and regional precipitation records, and their individual and combined impacts on flooding. A main period of large-scale, uniform and rapid deforestation in the catchment was identified in the early nineteenth century, but sub-catchment patterns of reforestation and regeneration have varied up to the present. The period of deforestation was accompanied by demographic expansion and regional scale exogenous forces, such as small scale industrial development, foreign occupation, war, caveats and laws, acting alongside local scale endogenous forces and land fragmentation, agricultural crisis, and the desire for pasture. These all produced conflict between individual needs and those of communities and resulted in localised changes in forest cover. Joint phases of deforestation and flooding are more evident in individual second order tributaries than the whole catchment, but there appears to be no obvious or simple causal link between forest cover change, climate anomalies and flooding.

Environment and History **8** (2002): 403–28
© 2002 The White Horse Press, Cambridge, UK.

KEY WORDS

Forest cover, deforestation, human impacts, climate change, flooding.

INTRODUCTION

Recent dramatic flooding events throughout Europe highlight the potential problems associated with a general warming in climate and an accompanying enhanced global hydrological cycle along with a predicted increase in the frequency and intensity of large precipitation events.[1] Since much of the most severe precipitation occurs in upland environments, research into the nature of global warming especially in mountain regions demands more information about the sensitivity of upland catchments to different combinations of land use and meteorological regimes.[2] It is crucial to understand forest responses to both human and climate-driven disturbances and stresses.[3] For a long time it has been argued that climate and forest cover changes may make significant impacts on hydrological systems,[4] and particularly during periods of cool and wet climate, such as the 'Little Ice Age'[5] and during periods of deforestation when changes to the frequency and magnitude of flooding have been observed.[6] The triggers for deforestation are manifold with diverse potential precursory causes, such as population increase and industrialisation.[7] Such issues now have renewed contemporary relevance especially in those upland areas where the traditional concerns of farmers and graziers have diversified to include those of rural planners, risk assessors, ecologists and tourists.[8] In this paper we attempt to demonstrate that an understanding of the relationships between patterns of land use and mismanagement and their impact on the French Pre-Alpine environment in the past may represent a powerful means for identifying and gauging correct management practices in the future.

The paper takes a case-study approach to reconstructing the history of forest cover, forest management and flooding in the drainage basin of the Annecy Petit Lac, Haute-Savoie France, an area of approximately 150 km^2. The primarily limestone drainage basin ranges in altitude from around 450 to 2200 metres above sea level and exhibits a variety of landscape elements, from the drained valley floor, to steep wooded slopes, farmed montane valleys at an altitude of 1000–1500 metres, and grazed pastures and sub-alpine ecosystems above the present day tree-line at about 1800 metres depending on aspect. The theoretical altitudinal limit for forest, recently modelled at around 2300 metres in the Swiss Alps,[9] is controlled principally by summer temperatures, aspect, lithology, water availability and grazing pressure. There are three main river and torrent systems that flow in to the Petit Lac: the Eau Morte-St Ruph; the Ire and the Bornette. The Eau Morte-St Ruph is the largest, draining about 54 per cent of the catchment with an altitudinal drop of about 1800 metres before flowing through ten kilometres of floodplain.

The conjunctions and events that led to deforestation between 1730 and 2000 are identified, and the changing characteristics of competition for woodland resources are discussed alongside the varied voluntary and regulatory responses to deforestation and flooding. These findings are then used to consider the main controls on flooding. Five general questions are asked:

- How and when did human impact affect the distribution of woodland?
- What controls on forest composition and area existed in the past?
- To what extent has flooding been affected by climate and deforestation, acting independently or together?
- What is the spatial variability of deforestation and flooding between 1730 and 2000?
- Which slope hydrology systems are most sensitive to the destructive effects of woodland removal?

METHODOLOGY AND SOURCES

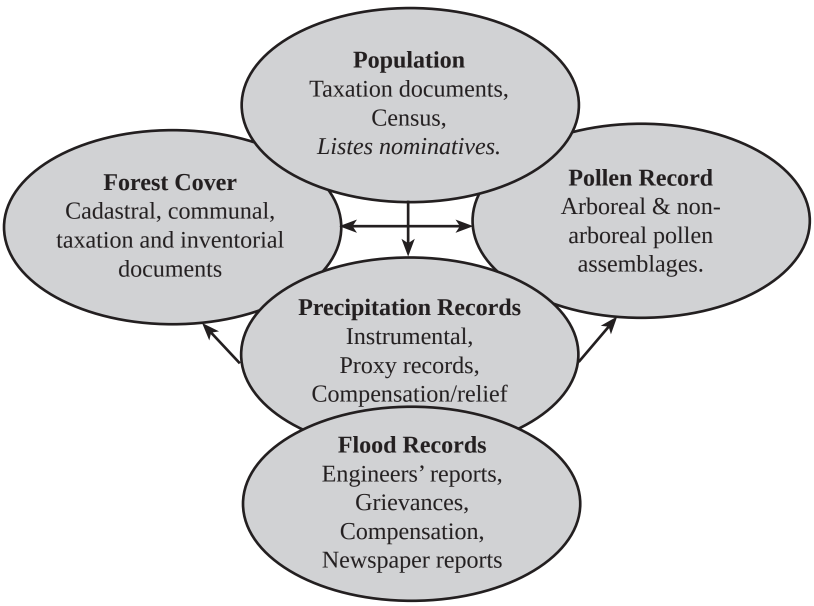

FIGURE 1. Methodological Framework.

The present research project at Lake Annecy uses an inter- and multidisciplinary approach to establish the effects of changes in climate and land use on hydrology in the Petit Lac catchment.[10] Part of this process focuses on the use of lake sediments to reconstruct the long-term changes in sediment delivery and erosion sources.[11] This paper focuses on the part that seeks to establish changes in forest cover and flooding using documentary archive sources. The methodology adopted here (Figure 1) includes the use of four different kinds of records: documented forest cover, a pollen diagram, flood events and instrumental meteorological data.

Earliest reference to forestry practice goes back to the monastic period around the ninth century,[12] but it is not until 1730 that a baseline quantitative figure for forest/woodland cover is available from the Grand Cadastral taxation survey 'Cadastre Sarde'.[13] Data from 1730 up to 2000 are standardised at either whole catchment or local commune scales using conversion tables and general land use categories to enable comparisons between census dates.[14] Alongside the documentary sources, a dated (^{14}C and ^{210}Pb) pollen diagram showing the dichotomy between arboreal and non-arboreal species derived from lake sediments in the Petit Lac provides an independent record for major forest changes.[15] Human population was reconstructed for the catchment between 1730 and 2000 using various enumerations and census data from the seven key parishes (Figure 2).[16] Pre-nineteenth century population reconstruction is based on informed estimates of households (*feux*) sizes and known numbers of feux.

Flood records are available in various forms from the sixteenth century onwards, but have only been used here for the period between 1730 and 2000, because of discontinuities in earlier records. Results are aggregated to avoid multiple counting of the same flood event as recorded in different rivers, although it is emphasised that extremely localised (around 1 km^2) storms could lead to flash flooding in tributary rivers that do not necessarily transfer themselves into the main Eau Morte river. For this reason, only those floods with known provenance and dating are included in counts. This enables two levels of enquiry: at the catchment scale; and at the scale of individual second order tributaries, whose interfluvial characteristics are definable in the contemporary political boundaries of communes.

Local precipitation records derived from Annecy are incomplete, but can be quantitatively linked with two precipitation indices from Annecy to form a continuous time-series from 1730 up to 2000. Annual precipitation indices (PI +4 Very warm/wet to –9 very cold/dry) from 1730 to 1791 overlap with the number of rain days in Annecy for the period 1773 to 1885.[17] A simple precipitation index is obtained from rain day data by calculating the deviation from the mean (over 133 days) for that period. In both precipitation indices a positive figure indicates wetter conditions and a negative figure drier conditions.

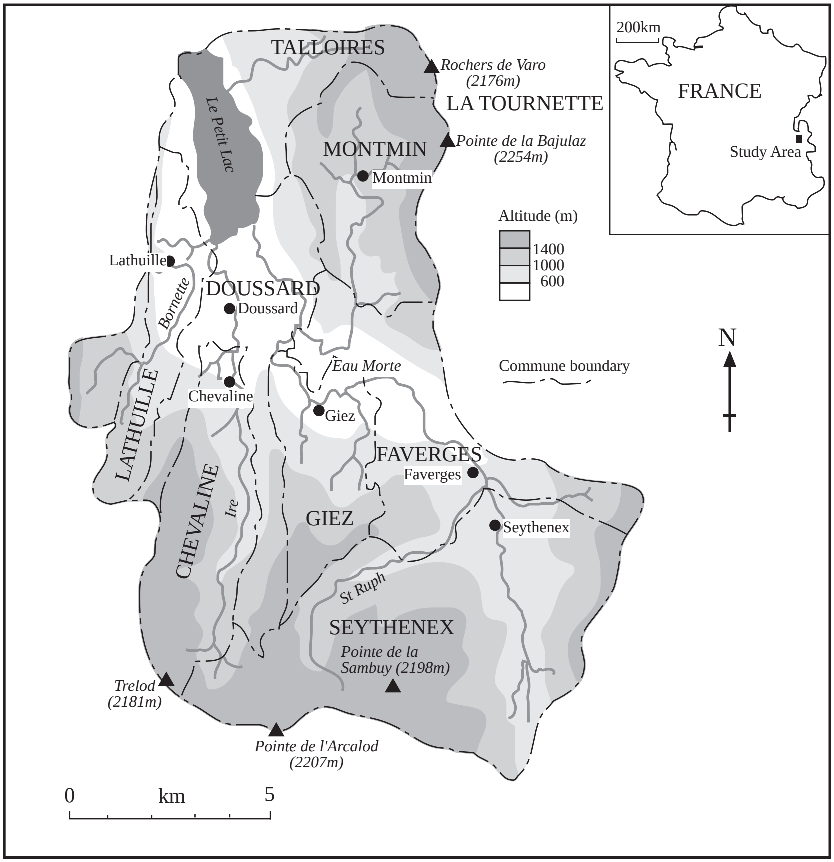

FIGURE 2. The Petit Lac Catchment.

These precipitation records in turn overlap with instrumental records at Annecy town between 1876 and 2000, but unfortunately these records have major gaps, principally between 1913 and 1933. A strong cross-correlation (correlation coefficient = 0.81) with the complete series (1826–1996) from the contiguous region of Geneva allows these gaps to be filled by a linear regression analysis (y=0.8188x + 253.92; R^2 0.6552) and for the local series to be extended back to 1826. The absolute values from the three records differ, but a five-year moving average identifies comparable trends.

RESULTS

The Forest Record

Forest cover in the catchment over the study period is characterised by a general trend toward deforestation beginning in 1760, a process that accelerates between 1820 and 1840, followed by a slow and gradual recovery up to the present (Figure 3a and b). This represents a decline from 50 per cent catchment forest cover in 1730 to 26 per cent forest cover in 1840 and a gradual recovery to 53 per cent forest cover in 1999. There is a fairly good association between the trends in the percentage of arboreal pollen (%AP) (Figure 3c) and forest cover over the documented period. Forest histories have not been uniform across the whole catchment, with greater variability evident in both deforestation patterns and the recovery pathways of individual communities forests than for the catchment as a whole (Fig 3b). Chevaline and Lathuille are the only communities where contemporary forest cover is below the 1730 baseline figure. The forest record is also divided up by ecclesiastical, communal and private ownership, which reflects differences in woodland management and use. It should be remembered that, apart from a brief period of occupation in the Napoleonic period, Savoy did not become part of France until 1860, and different rules applied. The explanation for these differences will be addressed in the subsequent discussion.

The major native high forest found in the catchment in the early eighteenth century was fir, beech, elm, and plane. Forest legislation and caveats appear from at least the middle part of the sixteenth century.[18] During this long period when the seat of government in Savoy was in Turin, however, much forestry legislation was based on conditions in Piedmont. So high forest management at the start of the eighteenth century was still based on the 1669 Forest Ordinance that referred to forestry practices in northern Italy. This meant that wood was usually cut in the autumn/winter in ten-year cycles from the age of around 30 years onwards. A second resource occupying a slightly smaller surface area in the catchment was coppice woodlands, which were grown either as separate stands or under mature trees on different rotations according to the species and management objective. Typical species used in coppice rotation included alder, oak, willow and hazel. Coppice woodland was extensively used, after drying, for charcoal production and household heating whilst also being used to provide more flexible and malleable handicraft and construction materials, and providing fruit and fodder. Viticulture and arboriculture developed in Roman times promoted the growth of vines, walnut, chestnut, and willow for fruits and oils, and ropes and resins for cooking, building and industrial processes.

Timber had for a long time provided an important means of generating private and community revenue; however, the pressure to exact short-term profits from wood collected from small and fragmented woodland plots increased throughout the eighteenth century with the need to pay new (e.g.

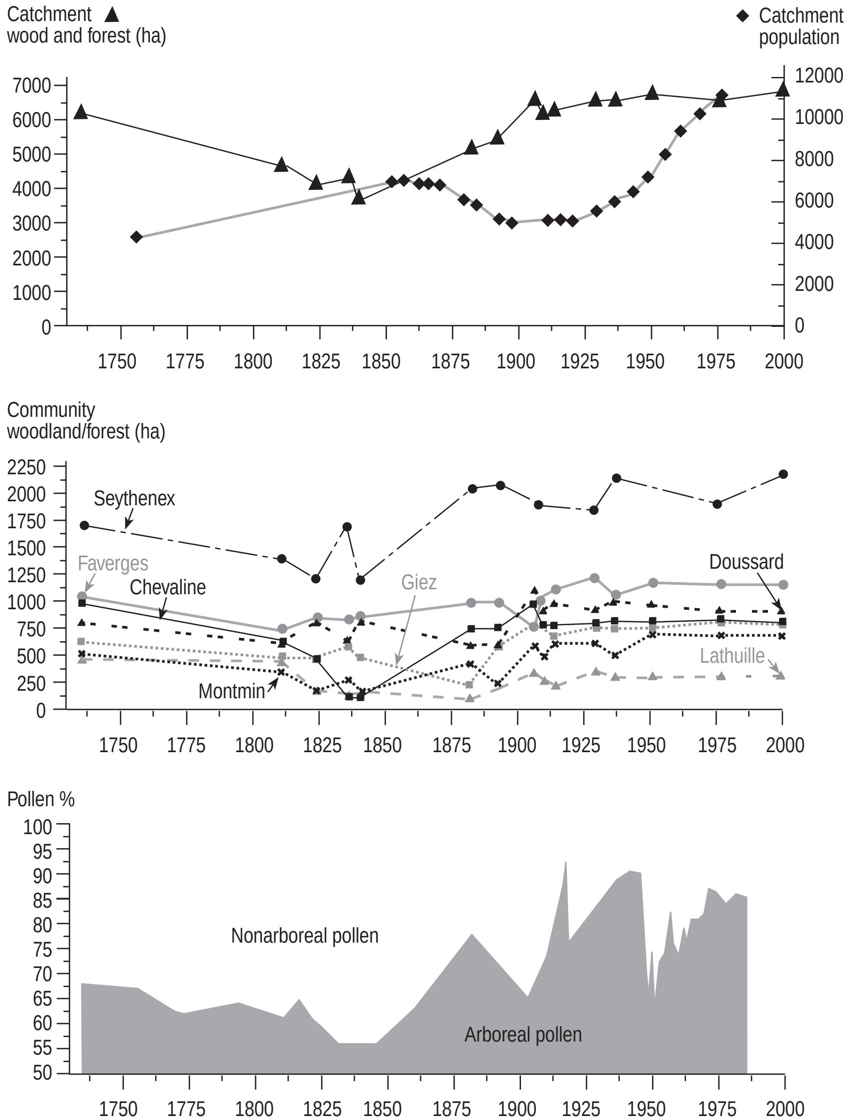

FIGURE 3. Changes to Forest Cover in the Petit Lac Catchment 1730–2000.

cadastral tax) and existing onerous taxes (e.g. salt tax), tithes and rents.[19] The fragmented landscape did not favour long-term forest management strategies because profits were not accrued within a single generation. This was one reason why coppice was preferred to high forest alongside the high labour costs of processing mature timber and poor accessibility to high forests. Thus farmers under the *'libre sortie'* regime exploited woodland resources before full maturity, which was understandable given the harsh economic conditions and the archaic agricultural system, particularly as the profits from the sale of wood were greater than the small profits to be gained from the sale of crops at local markets.[20] In 1723 the previous legal ruling (*arrêt*) on forestry was generalised for the whole of the duchy of Savoy and transcribed as a royal regulation (*règlement*),[21] showing that forestry problems were widespread. Centralised control was applied, although probably not always enforced, upon parish councils. The magnitude of deforestation problems was sufficient for King Victor Amédée II to prevent the export and exploitation of high forest and the clearance of wood in 1729.[22] These regulations also imposed an element of parish stewardship that required the need to reforest felled woodlands, whilst reiterating sensible grazing practices, which avoided young plantations. After 1729 the parish councils were unable to cut wood for sale without the authorisation of the Provincial forest steward (*Intendant*). Nevertheless there was still no effective State organised surveillance of woodland during this period when an ineffective nobility provided this role. The persistent out migration from communities probably further weakened these regulatory principles and caveats, leaving the absent owners powerless to prevent thefts and depredations by neighbours.[23] Further general forest regulations were released in 1730, but suspicions about their lax effectiveness of application and enforcement were invoked in 1749. The problem may not have been too great in the catchment as in 1754 community demands for wood remained below supply in all but two communities, Seythenex and Faverges, where supply matched demand. This suggests that, although cutting wood during inalpage on Mont Charbon and Planay in the Ire and Bornette catchments was prohibited in 1737, net deforestation was not occurring at this time. Quite clearly there is not enough evidence to suggest an explicit link between deforestation and the introduction of forest legislation, as arboreal pollen remained relatively high in the early eighteenth century and the forest record points only to a small decline in total woodland. However, by 1766 the State was sufficiently concerned about deforestation to readdress its forestry rights and regulations.[24] The Royal Constitutions of 1770 by Charles-Emmanuel III repeated the same prohibitions as the 1729 Forestry Ordinance in an attempt to control the destruction of the forests. Mining and metal manufacturing industries in the late eighteenth century required wood for industrial processing and fuel, with much coppice woodland in the catchment reserved for charcoal making. This charcoal was destined for forges located at the heads of interfluves. A large lignite mine, opened in 1793 at Entrevernes, also created a major new demand for local wood, particularly support stanchions and fuel wood from the Ire and Bornette catchments.

Population, which had fluctuated in the eighteenth century (Fig 3a), reached its highest pre-modern levels in a number of parishes in the early nineteenth century as out migration was curtailed by new state border controls.[25] People reacted by expanding the area of arable land. This could only be achieved by cultivating fields at higher altitude, which led to cultivation reaching its maximum altitudinal limit (*c*. 1400 m.a.s.l.) during this period.[26] The potato, introduced into the catchment at some time between 1770 and 1822, gradually replaced chestnuts as the most important staple in mountain diets, which led to a decline in the importance of chestnut trees.[27] The decline coincided with moves to improve and expand the pastures[28] that effectively competed with land suited for chestnut woodland.[29] Grazing had a detrimental affect on woodland regeneration as the increased need for high quality pasture for cattle forced people to graze large numbers of goats and sheep in young plantations. From the evidence provided by numerous caveats, total tree loss (Fig 3c) due to overgrazing by goats and sheep was a recurrent and cyclical problem throughout the eighteenth and nineteenth centuries.[30]

The law of 6 October 1791, when the duchy was part of France, is considered to be the start of the French forestry regime in Savoy, but it appears that attempts to increase forest cover were short-lived and ineffective. In the wars to overthrow Napoleon, Savoy came under the control of invading Austrian forces, which had a devastating effect on woodlands, particularly in the Tamie and Ire valleys. The ensuing timber crisis was so severe in the Ire valley that in October 1814, the people of Lathuille were forced to cut trees in the forest domain of Aillon outside the catchment.[31] New forest regulations, after the restoration of the dukedom, mentioned the disastrous time prior to 1822, when the destruction of wood in summer had denuded slopes, and spoke of the need for a revolution in the way that woodlands and forests were managed. The situation, however, did not drastically improve until the Duke of Savoy and Sardinia regained control of the duchy.[32] But the returned regime failed to administer communal forest with any well-defined regulations or a management plan. This apparently led to regular blanket cutting. The demand for wood in the catchment continued to rise at the start of the nineteenth century (Figs 3a and c) and further demands were made following the discovery of new mineral deposits and the reworking of old iron seams with improved extractive techniques.[33] By 1836 it was estimated that the valleys of one commune in the catchment alone, Doussard, had supplied a total of 130,000–150,000 fir trees (13–14,000 *toises* of timber) to Haute-Savoie markets, making it one of the two main suppliers in the region. Italian incursions into the area between 1831 and 1834 placed additional pressure on local timber resources.[34] Communal woodland in particular was felled, often illegally, to supply wood merchants who found poor peasants only too willing to exploit what were supposedly communal resources. These rapacious traders, enticed by the rising value of wood,[35] illegally exploited these increasingly scarce resources from at least the end of the eighteenth century to supply local and regional markets.[36] Infractions were commonplace and could be extreme with the clear felling of large areas of woodlands.[37] During this period of rule, i.e. before 1860, when Savoy finally became part of France, it was easy for regulations to be flaunted, with underpaid or unpaid forest guards often turning a blind eye to these activities. It is hard to imagine that such large-scale infractions as those seen in the Ire valley did not involve the collusion of whole villages. Whilst inhabitants could enter forests at all times and seasons to take wood at their discretion, illegal cutting increased.[38] Regulations and pecuniary fines were introduced to try and prohibit these practices, but these were ineffective as community councils did not push to reorganise forest management and there was opposition from municipal magistrates who failed to prosecute criminals. Regionally the pressure on woodland resources between 1846 and 1853 was often sufficient to reduce the length of coppice rotations.[39] Together all of these factors resulted in a ravaged woodland resource in the catchment in the early to mid nineteenth century that is reflected in both the documented forest cover and the low per cent arboreal pollen count (Figure 3).

It was not until the Treaty of Turin in 1860 and the incorporation of Savoy into the French state that a long-term woodland management strategy was initiated. Reports from this date express the view that most communes in the catchment inherited a very poor and depleted woodland stock that were loosely managed as one to two large high forest sections, and a smaller coppice section. Plantations were generally gardened on a 16-year sequential cutting regime followed by a final blanket cut at around 144 years. This cutting periodicity appears to have changed little since this time. A far greater range or series of coppice undergrowth rotations were operated in each commune from 24 years to 48 years, with three main cuts. The era of massive deforestation in the region was closed, but changes in practice and woodland regeneration clearly occurred over a long period of time. Reasons for this included the location of private woodland plots next to communal plots. This made it very tempting to encroach upon the community resource that was itself fragmented into smaller forest units known as *cantons*. This temptation was obviously heightened during times of stress, whether induced by climate or economic forces, or both. A retraction of reforestation law in 1864 also meant that a total commitment to reforesting upland areas was replaced by the option to re-turf mountainsides and tops.[40] A growing tide of opposition to the forest code in 1867 also led to community based calls to allow further grazing concessions, particularly during times of water shortage, as happened in 1870. On top of this, the sale of timber continued to involve the nefarious activities of unscrupulous wood merchants with infractions only dropping slowly throughout the second half of the century.[41] The increase in total forest cover during the second half of the nineteenth century (Fig 3a and c) reflects forest recovery in the relatively large community of Seythenex, as much as anything, and it masks further phases of clear felling in smaller communities. For example, from 1894 to 1899, 182 hectares of ancient 'virgin' forest, situated on the left hand bank of the Ire, was clear-felled for military purposes. It was probably this type of disruptive procedure that led to the disappearance of brown bears from the catchment forests in the late nineteenth century.[42] The punctuated recovery in the more highly resolved per cent arboreal pollen record (Figure 3c) at this time is perhaps a response to these oscillating and fluctuating communal circumstances.

At the end of the nineteenth century there were financial advantages to be gained from converting forest to improved upland pastures. This placed a further pressure on the woodland resources in these vulnerable environments as village interests, such as autonomous milking collectives (*fruitières*), clashed with the regulatory forest bodies.[43] Land fragmentation, agricultural crisis and the desire for pasture all pushed individual needs against those of communities and resulted in localised changes in forest cover. This probably accounts for the decline in forestry seen in the private sector in Lathuille and later deforestation phases in Giez, Doussard, Montmin and Faverges. The nineteenth century extension of pasturelands resulted in a localised lowering of the tree line. Extreme weather events also indirectly impacted on forest cover. Timber framed buildings, especially mountain chalets, remained vulnerable to violent summer and autumn storms (especially between 1860–1880), heavy winter snowfall and fire. Thus, community councils frequently had to respond to emergency demands for new timber. In fact, between 1883 and 1945 in Lathuille, extra-ordinary cuts became almost as frequent as the annual ordinary cut.

The structure of woodlands was also changing. Detailed communal forest records demonstrate that the woodland resource of Giez was shifting towards silviculture in the first 20 years of the twentieth century with broadleaf trees being replaced by pine, which allowed a major increase in tree volume. A similar picture emerges in the commune of Chevaline, although the figures point to earlier plantation, and a recent major switch to hard wood at the principal expense of spruce. There was also a clear shift away from coppice rotation towards plantation forestry at the turn of the twentieth century, a process which mirrors that seen in Switzerland.[44]

The longer growing periods associated with high plantation shows a reduced reliance on wood as an everyday household resource and a genuine move from small-scale industry to full industrialisation with an attendant switch in technology and energy sources. The burgeoning population of the mid-twentieth century mainly reflects a process of urbanisation in the catchment, with the main growth on the floodplain in the town of Faverges and in Doussard.[45] This trend, along with a decline in pastoral farming and increased reliance on summer tourism, has allowed a steady regeneration of the woodland resource up to the present day. The impacts of winter ski developments are limited to the Peak de Sambuy, and on a much smaller scale in Montmin. The recent increased planting of broad-leaved species reflects emerging ecological concerns about species composition.

The Flood Record

In hydrological terms the catchment is characterised by floods linked to snowmelt and summer thunderstorms, which usually occur each year, and autumn/winter depressions and frontal systems. It is presumed that documented floods are those which were observed to cause damage or perceived to be especially severe. The earliest reliable and plentiful documented flood records appear in the eighteenth century, although it is clear that flooding had been an intermittent problem in the catchment from the late seventeenth century.[46] The compiled record for the timing and frequency (but not magnitude) of floods in the catchment (Figure 4a) and individual sub-catchments 1730–2000 (Figure 5) demonstrates that flooding was a recurrent problem in the middle of the eighteenth century and then

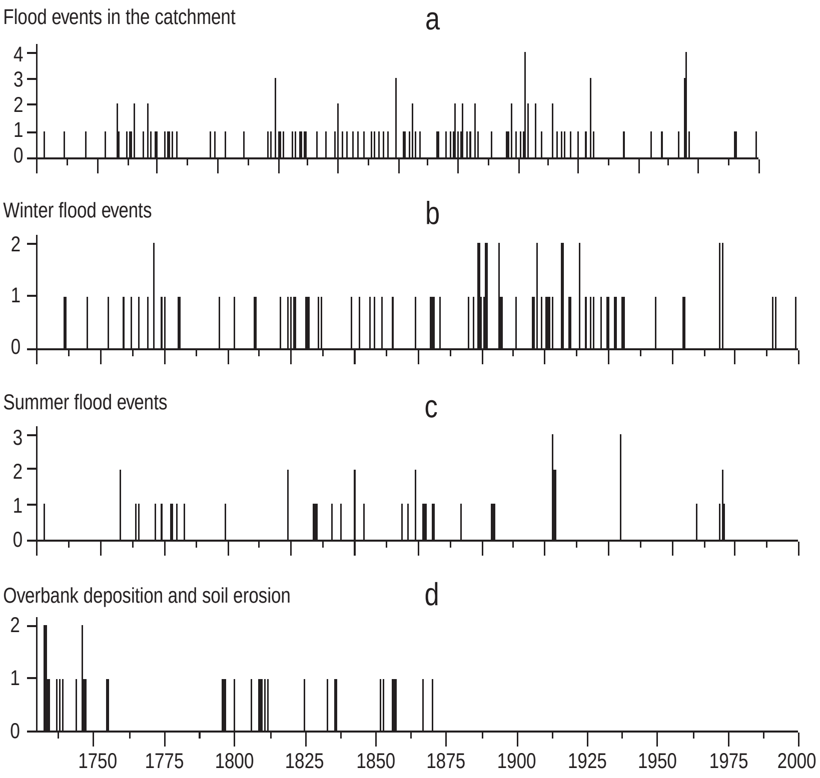

FIGURE 4. The Seasonal Characteristics of Flooding and Erosion in the Petit Lac Catchment 1730–2000

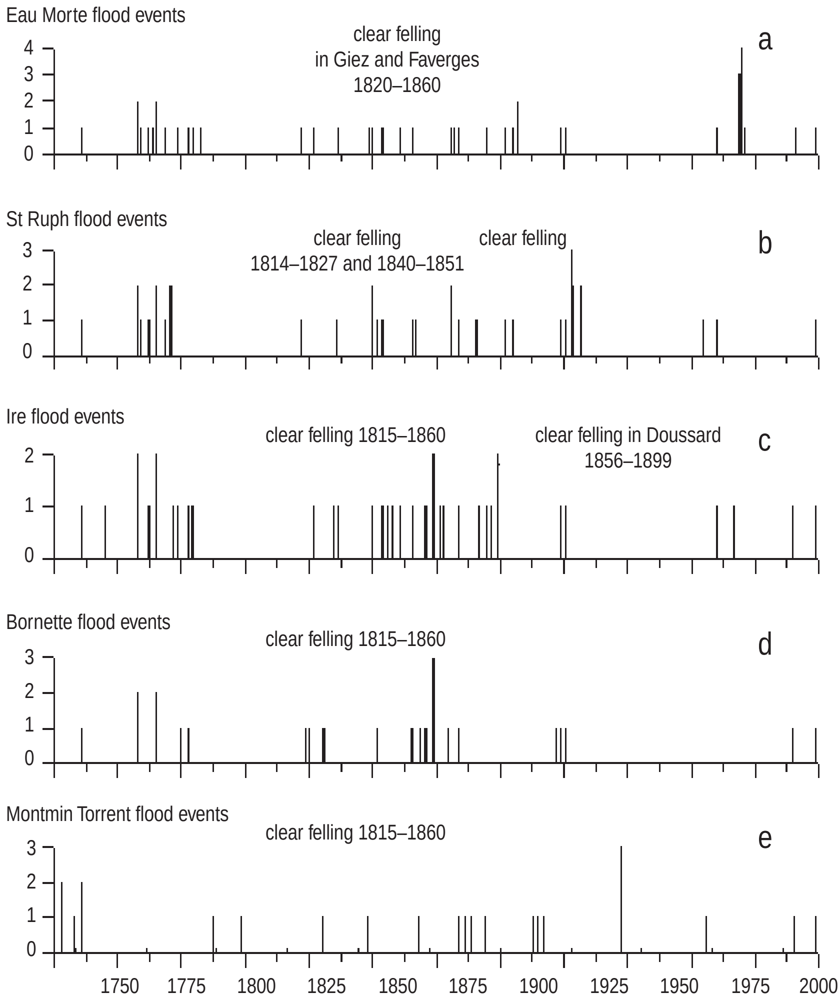

FIGURE 5. Sub-catchment Flooding in the Petit Lac Catchment 1730–2000

throughout the whole of the nineteenth century, with the floods of 1856 and 1859 documented as particularly destructive, and into the first quarter of the twentieth century. The highest annual frequency of floods in the catchment occurred in the years 1799, 1849, 1903, 1930, 1969 and 1970, although the last two dates may reflect more sensitive instrumented recording methods as opposed to real differences. The record is dominated by winter/spring floods (November to April inclusive, Figure 4a), but for three periods in the eighteenth and nineteenth centuries (1733–1757, 1809–1828 and 1844–1856) when summer/autumn (May to October inclusive, Figure 4b) floods dominate, especially in the Bornette (Figure 5d). The early eighteenth century channel changes and erosional characteristics of the floods demonstrate a volatile and motile high-energy hydrological system. The St Ruph and Ire rivers figure heavily in flood accounts during this period.

A general problem of flooding was officially recognised in Savoy as early as 1729 with the issuing of general legislation, which sought to control the on-going problem of continual and frequent flooding in torrents.[47] This problem extended to the catchment with major corrective works (e.g. dyking) carried out on the Eau Morte in the vicinity of Faverges after various floods of the St Ruph between 1734 and 1744 (Figure 5b). During these floods ephemeral flood channels were created (Figure 6), which redirected water southwards out of the Petit Lac catchment and into the Isère catchment.[48]

Thus, hydraulic engineering remedies were already a feature of the catchment at this time. The Ire, which suffered from severe flooding in the 1730s to 1750s (Figure 5c), was referred to as one of the most formidable torrents in the Province according to a deliberation of the three parishes of Doussard, Chevalines and Lathuile in 1750. Floods in the Ire, St Ruph and Bornette between 1730 and 1760 were characterised by major overbank deposition of gravels, soil erosion

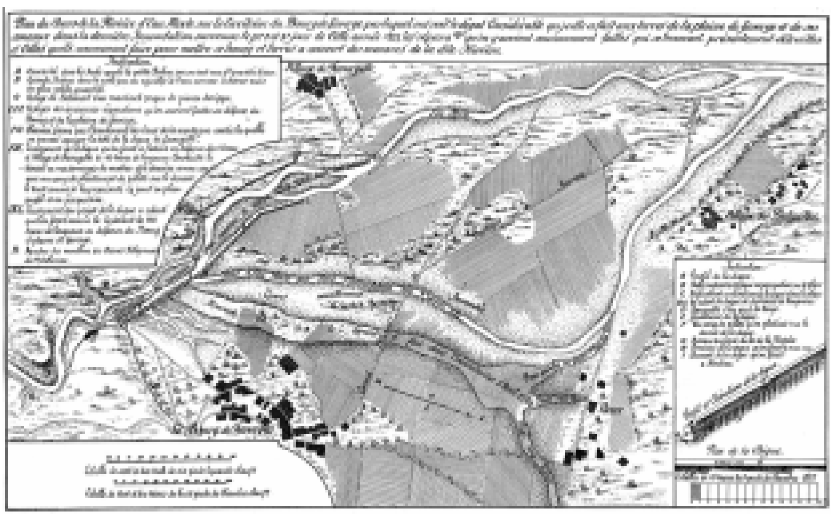

FIGURE 6. The Course of the 1734 and 1737 Floods in the St Ruph and Eau Morte Rivers. (Reproduced from Mougin, 1914)

on agricultural land, channel change and meandering (Figure 4d).[49] For example around nine hectares of diverse agricultural land in Chevaline was irreversibly lost to flooding and erosion caused by the Ire at this time. In addition to direct damage to land, crops and buildings, flooding of the St Ruph and Eau Morte in 1739 was also blamed for disease in the vicinity of Villard (Faverges commune).

By 1804 a legal decree imposed an obligation on riparian owners to carry out flood defence work. One of the main reasons given for flooding was the failure of riparian owners to clean out coarse and large flood debris from channels, however, the excavation of large aggregates provided a commercial opportunity in a few locations near the Eau Morte delta. The reworking of channel sediments on to fields could produce a better soil growing medium, although this was an easily crossed threshold as too much sediment and stone deposition reduced soil fertility and made soils unworkable even with ploughs, thus destroying the commercial value of the field. The 1804 decree obviously failed to have a major impact in the catchment as flooding of the Eau Morte and its affluents in October 1825 (Figure 5a) was described as ‘extraordinary’. In 1860, responsibility for care and defence against incursions from torrents still lay with riparian owners, but central intervention was also increasingly required to stem the flooding problem as riparian owners frequently requested assistance to repair damage and compensate losses caused by flooding.[50] Indeed State intervention in flood defence was introduced for the first time in 1860 after the Treaty of Turin ceded Savoy to France. The potential flooding problem in the Ire catchment is evident at the end of the nineteenth century when, in January 1899, a flood damaged 800 hectares of fields.[51]

Following this event, the numerous hydraulic engineering remedies designed to counteract flooding and erosion on the Ire in the nineteenth century culminated with the straightening and dyking of this channel at the beginning of the twentieth century.[52] Thereafter flooding is ameliorated and the frequency of recorded floods declined (Fig 4a and b). Similarly all major torrents in the catchment went through a process of correction, straightening and remedial maintenance throughout the late nineteenth and early twentieth centuries. Thus, the dramatic decline in flooding seen in the latter parts of the twentieth century is a product of these works building on the public and private works of the previous centuries. Since then, energy from floodwaters is now transferred more rapidly through the hydrological system to the managed lake system. However, the Montmin torrent suffered from major floods in the 1930s (Figure 5e), and the Ire and St Ruph rivers have flooded sporadically throughout the twentieth century. The high number of floods recorded in 1969 and 1970 marks improved methods of recording discharge rather than a comparable upward swing in flood frequency.

The Climate Record

A five year moving average establishes general trends in annual precipitation in the catchment between 1730 and 2000 (Figure 7). In the eighteenth century a short wet period between 1773–1782 punctuated the most prolonged period (1730–1772) of dry conditions in the 270-year precipitation record. The nineteenth century begins with two wet phases 1801–1818 and 1839–1847, which were followed by dryer conditions until 1875. This date marks the beginning of the wettest phase (1876–1939) in the catchment over the study period. In general, rainfall has tended to increase over the nineteenth and twentieth centuries with oscillating wet and dry periods of around seven to eight years. The wettest individual years over the study period were 1755, 1762, 1781 (PI > 3) 1801 (PI >39 rain days), 1841, 1878, 1882, 1922, 1960 and 1965 (RF >1700mm year^{-1}). Very dry years in 1758, 1770 (PI < -6), 1798 (PI < –110 rain days), 1832, 1837, 1857, 1906, 1921, 1949 and 1989 (RF < 900mm year^{-1}) tended to precede wet years.

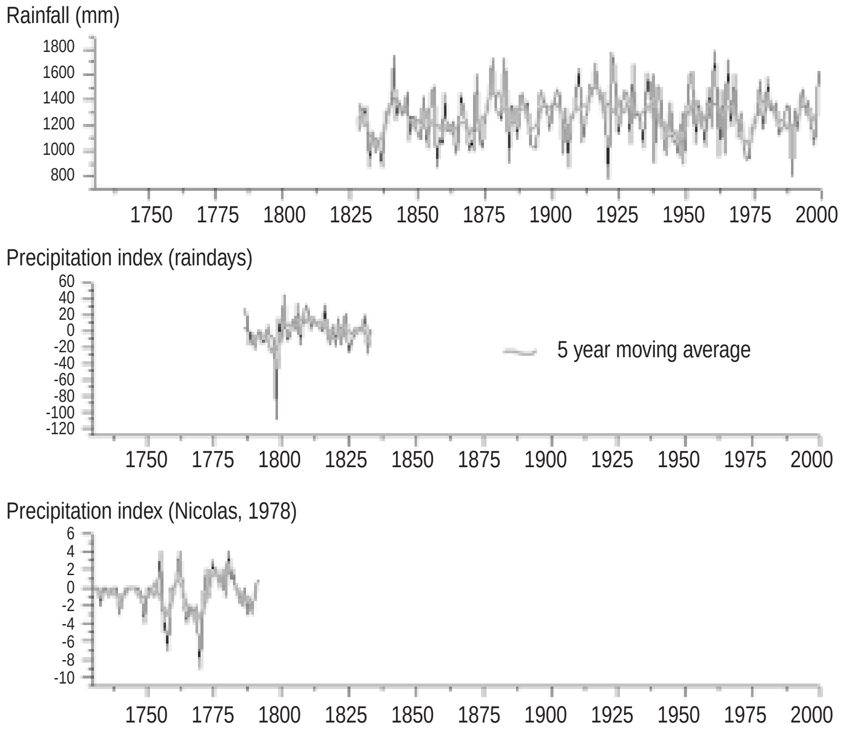

FIGURE 7. Trends in Rainfall, Annecy 1730–2000.

DISCUSSION

Forest Management

Human impact on woodland in the period covered by this paper is an oscillating story of growth and stability (1730–1819) followed by rapid deforestation (1820–1840) and then protracted and variable regeneration (1850–2000). Both exogenous and endogenous forces acted at the local and regional scales to induce forest cover changes. The main controls on forest composition and area changed over time. In the eighteenth century there were emphases on human and animal dietary requirements, and on heating fuel and building timber characteristic of a semi-subsistence economy. This favoured a more diverse species assemblage than in latter periods. During this time, individual species like chestnut and walnut, and management practices such as coppicing, were important. It appears that both state and community forest laws and caveats were able to slow the rate of deforestation throughout the eighteenth century, perhaps demonstrating that the political and social system of the time was sufficiently aware and adaptable to avert a major environmental crisis.

The growing population in the catchment at the end of the eighteenth century and in the early nineteenth century was no longer able to resort to out-migration as a strategy of accumulation, because of stricter control on borders.[53] This forced people to occupy land for cereal cultivation on higher slopes previously laid down to woodland. Dietary improvements accompanied these changes with a reduced reliance on woodland fruits and nuts in the diet. The dryer and slightly warmer phases of the climate in the late eighteenth century may have facilitated this upland shift in cultivation, but sensitive environmental thresholds could easily have been crossed rapidly with the wetter and colder conditions in the first 20 years of the nineteenth century.[54] Certainly in this period there was a greater reliance on selling wood just to sustain a livelihood, particularly in upland locations like Montmin and Seythenex. Other forces were also at work. Lignite mining, iron processing and military demands for wood were coupled with the rapacious attitudes of financially stretched farmers who often illegally exploited contiguous fragmented woodland plots belonging to absent landlords. It was these factors that resulted in catchment wide deforestation in the early nineteenth century, which is clearly picked out in the pollen record. During this period, wood became an increasingly scarce resource and valuable item in peasant livelihoods. This led to a move towards more rapidly growing species and to increased coppicing, but also to localised clear felling.[55] Under the Sarde regime (1815–1860) clear felling favoured the development of broad leave species and spruce in areas preferred by pine.[56]

The history of forest growth and regeneration within the catchment has equal importance to that of deforestation.[57] Woodland recovery and regeneration after 1860 was facilitated by changing technologies in fuel and power and improved woodland management, particularly in communal woodlands. A more balanced and consolidated approach to forestry allowed a greater emphasis on high forest growth in large stands and a concomitant reduction in coppicing. However woodland regeneration was protracted and has marked sub-catchment variability. The divergent interests of foresters and agro-pasturalists particularly during the late nineteenth and early twentieth centuries can account for some of this sub-catchment variability, with upland forests being particularly vulnerable to these pressures. Likewise modernising communities continued to use wood sales as a means of raising communal funds. Council minutes for communes in the catchment, with frequent references to special arrangements for felling timber, suggest that deforestation should have been a widespread problem at the end of the nineteenth century, but the forest record does not reflect these concerns. Whilst restructuring of forestry for silviculture might mask some of these changes in total forest cover, and although the pollen record appears more sensitive to these, it does not explain why there was no significant reduction in total forest cover. This suggests that small-scale disruptions of woodlands, which may have micro-scale environmental consequences for a local community, are hidden from the official statistics, perhaps because these woodland patches do not lose their character as woodlands.

Since the end of the Second World War, some of the pressures on forest resources have reduced as upland populations have declined and a process of persistent urbanisation has affected the lowlands. Likewise the decline in the importance of agriculture to household incomes, particularly in mountain communities, has allowed forest regeneration. In the last 20 to 30 years summer tourism has lent itself to improving woodland biodiversity, which has resulted in localised reintroduction of eighteenth-century management practices. These in turn promote the regeneration of tree species from earlier periods. Moreover, the wetter and warmer conditions of the twentieth century have encouraged forest growth.

Forestry and Flooding

At the start of this paper the question was raised about whether a cause and effect relationship between deforestation and flooding could be established. The idea that deforestation and clearance in the mountains have contributed to landslides and erosion has been known since the earliest period of major clearances in the twelfth century.[58] It is re-reflected in the periodic bans and restrictions on grazing in woodlands by sheep and particularly by goats. Flooding that occurred in the first half of the eighteenth century was not attributed so much to deforestation, however, as to on the failure of riparian owners to clean out riverbeds that had been filled and blocked by sand and gravel. This might suggest that an increased sediment delivery was linked more to purely climatic causes than to a high level of upland disturbance and erosion.

In contrast, forestry statutes and regulations proved insufficient to stop both exogenous and endogenous forces from working together to drive the major, uniform and rapid phase of deforestation in the early nineteenth century. It was during this disruptive period that people began to make direct links between deforestation and increased flooding. Faverges municipal council in 1828 attributed increased flooding of the St Ruph to woodcutting in forests on Montriond and Mont-Verdan. As a result, the council requested a prohibition on clear felling of trees in the forest basins of Tamie, Seythenex and Mont-Verdan. As such, the destructive practice of clear felling appears to have had the most dramatic impact on flooding in the catchment in a period when its effects may have been amplified by the wet years of 1801–1818. Joint phases of blanket cut deforestation and flooding are more evident at the scale of individual second order tributaries, particularly in the Ire records during the nineteenth century, than the whole catchment, but there is no obvious causal link on an annual basis between the two phenomena. These deductions, however, remain based solely on the knowledge of the timing and annual frequency of floods and not the flood magnitude.

Gradually, general remedial laws were introduced (e.g. 28 July 1860) that had the aim of reforesting the summits and sides of mountains to correct flooding in torrents.[59] Further general laws passed in 1874 and 1882 both sought specifically to restore mountain terrain, although only non-degraded surfaces, with work by the state and private owners again being supported by state grant interventions.[60] A local reforestation programme and new forest regulations accompanied the numerous hydraulic engineering remedies designed to counteract flooding and erosion on the Ire in the nineteenth century.[61] However, clear-felling continued and was still perceived to be causing flood problems in the Ire. For example, clear-felling of the virgin forest in the Ire catchment between 1859 and 1899, within a noticeably drier period, was blamed for making the Ire torrent ‘furious’ with flash floods transporting large volumes of soil and rock debris, demonstrating that old habits died hard![62] The decline in flooding seen in the last three quarters of the twentieth century is a product of the public and private works of the previous centuries and a stable level of forestry that absorbs and slows down runoff processes.

Flooding and Climate

The final question asked was whether a linkage could be made between deforestation, flooding and wetter climatic phases. Evidence from documentary sources points to the flooding of the 1730s to 1750s being caused by deteriorating climatic conditions. In particular there were heavy snowfalls leading to large snowmelt events. No periods of increased wetness coincide with these events, which lends support to the idea that the concurrence of large snowmelt and heavy rainfall events created these problems, as opposed to overall wetter years. This view is supported by the fact that a wet phase between 1773 and 1782 did not translate into increased flooding.

Major deforestation events in the early nineteenth century coincided with two wet phases (1801–1818 and 1839–1847) and flooding, but the flooding problem peaks at around 1845–1860 when the annual climate is once again drier. Flooding at this time is characterised by more summer floods, which suggests either a changing seasonal weather pattern or a non-climate trigger for increased flooding. With the exception of May 1856 (465 mm), monthly summer rainfall does not appear exceptionally heavy, or frequent during this period.[63] However the magnitude of individual storm events remains unknown. The documentary record attributes increased flooding at this time to uncontrolled deforestation particularly in the Ire and St Ruph catchments, but it seems more likely that a combination of higher magnitude convective storms along with deforestation increased the frequency of flooding. Alternatively the deforestation in the early wet periods made the environment more sensitive to flooding, or summer storms in particular, around 1850.

Late nineteenth-century and early twentieth century flooding coincides with a very wet climate phase. This was a problem made worse by continuing severe and destructive convective summer and autumn storms and further sub-catchment deforestation. After this date the frequency of recorded extreme flood events reduces as technical improvements, such as improvements in dyking, which built on the public and private works of the previous centuries, ameliorated flooding. This had the effect of decoupling the documented flood record from the climate record, with particularly harsh winters, such as 1941, not translating into floods that caused damage.

Thus the combined evidence from forestry, climate and flood records strongly suggests that flooding in the catchment since 1730 has been driven by a combination of human activities and climate change and events, sometimes working in unison and at other times totally decoupled. This suggests that deforestation has not been the sole cause of destructive flooding over the whole period, but at specific times has exacerbated the flood problem at certain locations and in certain tributaries. For example, the Ire valley and north facing slopes of the Tamie/StRuph valleys may be identified as particularly sensitive to changes in flood runoff and sediment delivery following deforestation. Deforestation in these locations in the past has been linked with the documented increased frequency and magnitude of flooding in the Ire and St Ruph and the fact that contemporary woodlands here therefore require prudent management.

CONCLUSIONS

- Human impact led to a major phase of deforestation in the catchment in the early nineteenth century. Patterns of reforestation and natural regeneration differed in individual communities, but contemporary forest cover in the catchment has now grown beyond the levels recorded in the first cadastration of the 1730s.
- Controls on forest composition and area came from exogenous and endogenous socio-economic and political forces acting together with local population dynamics and management practices.
- Deforestation throughout the catchment probably enhanced the effects of summer flooding in the mid nineteenth century, when climate was overall cooler and drier but with an increasing frequency of summer convective storms.
- Sub-catchment deforestation during a general phase of reforestation and regeneration in the catchment enhanced flooding particularly in the Ire and Bornette rivers in the late nineteenth century.
- The hydrological and sediment regimes of the steep slopes in the Ire valley and north facing slopes of the Tamie and St Ruph valleys are most sensitive to the destructive effects of woodland removal.

NOTES

This project has been kindly funded by the Leverhulme Trust (Grant No F/25/BQ) and fits within the IGBP/PAGES Focus 5 initiative ‘Human Impacts on Terrestrial Ecosystems’. We gratefully acknowledge and thank Fernand Berthier, secretary of CLIMASILAC, for his assistance in data collection and resolving copyright issues.

[1] Cf. Houghton, 2001.
[2] Ives and Pitt 1988.
[3] Ives and Messerli 1989, Foster et al. 1997, 1998; Bürgi et al. 2000.
[4] Sclafert 1933,Ives and Pitt 1988, Guidoboni 1998, Mather and Fairbairn 2000.
[5] Grove 1966, Le Roy Ladurie 1971.
[6] Mougin 1914.
[7] Sclafert 1933, Darby 1956, Slicher Van Bath 1963, Glacken 1967, Bürgi 1999a, Bürgi 1999b, Williams 2000.
[8] Mahapatra 2001.
[9] Bugmann and Pfister 2000.
[10] http: //www.liv.ac.uk/geography/levan
[11] Higgitt et al. 1991, Dearing et al. 2001, Noël et al. 2001, Foster et al. in press.
[12] Bernard 1967, Chavoutier 1977: 1–24.

[13] Bruchet 1977, Vayssiere 1981.
[14] D'Helens 1996: 25–32.
[15] Noël et al 2001; Whilst the dates are good the level of resolution in the sampling of these cores makes it impossible to establish an accurate annual resolution, rather it is only possible to draw general conclusions about shifts in forest cover from the pollen record.
[16] Siddle – unpublished data.
[17] Nicolas 1978: 581; Tissot 1887: 2–7.
[18] For example, legal rulings *(arrêts*) on forestry from the Sénat of Savoie on the 8th and 19th May 1559.
[19] Siddle 1997: 4–5.
[20] Montmayeur 1865: 62; Tochon 1871: 34–36.
[21] Royal *règlement* of 7 août 1723, livre 4 titre X.
[22] Royal Constitutions of 11 July 1729 livre VI, titre IX, article 7.
[23] Siddle 1997: 1–20.
[24] The Sénat of Savoie Arrêt 5/7/1766 Titre IX.
[25] Incomplete records for all 7 parishes make it impossible to provide a catchment estimate, but populations in Doussard (1010), Montmin (679) and Giez (522) peaked in 1822 and Seythenex (1305) in 1783.
[26] Cholley 1925.
[27] *Castanae* sp. do not decline in the pollen record until the early 20th century, which suggests that uprooting did not occur until much later.
[28] Beauregard 1812: 235–245; Tochon 1871: 37.
[29] Foster and O'Keefe 2000: 6.
[30] Dates of caveats during this period include 1729; 1766; 1770; 1791; 1793; 1796; 1808; 1822; 1861; 1866; 1868 and 1876.
[31] Mougin 1914: 109.
[32] Privat 1973: 470.
[33] Further discovery of iron at Sambuy led to major development of this industry between 1816 and 1830 based on the original structures/locations of the Cistercian monks.
[34] Mougin 1914: 107–108, Privat 1973: 470.
[35] M. Papa, inspector of forests estimated that 1 hectare of 20 year old coppice had a market value of Fr 66 in 1747, Fr 600 in 1786, Fr 1000 in 1805 and Fr 2500–3000 in 1853 (Tochon 1871: 34–36).
[36] Pap Chambéry Forest Inspector, 1853. Wood merchants and markets were based in Doussard, Annecy and Albertville.
[37] Mougin 1914: 116.
[38] Between 1841 and 1850 the very best wood from the forests divided between Doussard, La Thuille, Chevaline and Giez were cut at night by local criminals who took it to their sawmills before transportation to the Annecy market.
[39] Mougin 1914: 117.
[40] Mougin 1914: 204.
[41] C. 1853 – 8,000 forestry contraventions/year were reported amongst a population of 25,000 in Savoy, 1861 = 3,826; 1881 = 2,344; 1901 =1,521 (Mougin 1914: 117).
[42] Serand 1935: 90.
[43] La Thuille Registre de Délibérations du Council Municipal. p.287: Séance 9/2/1890. The Municipal council asked the forest administration to reduce the extent of the forest in La Combe (6 ha) to increase the amount of pastureland.

[44] Mather and Fairbairn 2000: 399–421.
[45] Steel 1981: 263.
[46] Mougin 1914: 568.
[47] Mougin 1914: 198.
[48] Mougin 1914: 577.
[49] This process started outside the study period in 1711.
[50] Mougin 1914: 202.
[51] RTM – Municipal archive – Chevaline 11 Jan, 1899.
[52] Mougin 1914: 592 points to plans for major works on the Ire not completed until the twentieth century.
[53] Siddle 1997: 1–20.
[54] Pfister 1993.
[55] Exportation des bois du Royaume. Rapport sur l'exportation des bois du Duché de Savoie 24 août 1836
[56] Office de Forêt, Communal Archive – Chevaline
[57] Radkau 1996: 65.
[58] Bernard 1967; Chavoutier 1977: 1–24; Mougin 1914: 94.
[59] The state provided grants for seedlings and young plants (Art 1) and financial primers (Art 2). Mougin 1914: 203
[60] Mougin 1914: 208.
[61] Silviculture was carried out in the canton of Clafort (25.78 ha) in the Combe d'Ire, Chevaline to prevent fairly regular landslides. The forest cantons of Fontaine-Gueby (37.78 ha), Selliere (50.76 ha) and Patay (44.64 ha) are also planted on very steep (25–90 %) and loose slopes directly above the Ire known to be vulnerable to mass movement.
[62] Mougin 1914: 589.
[63] Monthly summer rainfall (May/June/July/August/September) from Geneva was plotted from 1826–1996, because monthly data for the period 1845–1860 from Annecy was not available.

ARCHIVAL SOURCES

Archives départementales de Haute Savoie (ADHS)

ADHS Series ICd Cadastre Sarde – Mappes, livres d'estime et geométrié, griefs.
ADHS Sous serie 33L Cadastre Imperial c. 1811
ADHS Cadastre Française. 1905–1913
ADHS 11 J 901 Exportation des bois du Royaume 24 août 1836.
ADHS 11 J 904 Capitainerie de stupinis
ADHS 11 J 905 Reglement forestier: Revision du Reglement forestier du 15 octobre 1822
ADHS 2Mi 110–111 Consigne du Sel. 1754
ADHS VC 25 f 425 and f 430
ADHS 7M 100 and 7M133–135.
ADHS Cor. De l'I. De G. avec M de l'I., 1825, no 365.
ADHS Cor. De l'I. De G., avec les com., 1827, no 658; 1828, 137.

Archives départementales de Savoie (ADS)

ADS Serie C. no 158, folio 133 1749.
ADS L no 77 bis 1791;
ADS Lathuille L180 f131
ADS Serie L no 1764 – Year 1814.

Albertville Archive (AA)

AA Corr. de l'I. Avec les forêts 1837–1844, 20 janvier 1840, 24 mars et 3 avril 1841. Avec les syndics 1846–1853 Passim).

Commune Archive Lathuille

Registre de Délibérations du Council Municipal 1883–1945.

Annecy Municipal Council archives

Office de Forêt and Restauration des Terrains en Montagne Commune records.

REFERENCES

Beauregard, C. de (marquis) 1812. *Essai sur l'amélioration de l'agriculture dans les pays montueux et en particulier en Savoie*, Chambéry, 1773; in 8^{o},2^{e} édition, Paris.

Bernard, F. 1967. *L'abbaye de Tamié, ses granges 1132–1793*, Grenoble, Allier.

Bruchet, M. 1977. *L'Ancien Cadastre de Savoie*, Annecy Archives départementales.

Bürgi, M. 1999a. How Terms Shape Forests: 'Niederwald', 'Mittelwald' and 'Hochwald', and their Interaction with Forest Development in the Canton of Zurich, Switzerland. *Environment and History* 5: 325–344.

Bürgi, M. 1999b. A case study of forest change in the Swiss lowlands. *Landscape Ecology* 14, 567–575.

Bürgi, M., Russell, E.W.B. and Motzkin, G. 2000. Effects of postsettlement human activities on forest composition in the north-eastern United states: a comparative approach. *Journal of Biogeography* 27: 1123–1138.

Bugmann, H. and Pfister, C. 2000. Impacts of interannual climate variability on past and future forest composition. *Recent Environmental Change* 1: 112–125.

Chavoutier, L. 1977. Des Moines Cisterciens aux Paysans Savoyards: La Creation des Alpages, *L'Histoire en Savoie* 46: 1–24.

Cholley, A. 1925. *Les Préalpes de Savoie (Genevois, Bauges) et leur avant-pays. Etude de Géographie Régionale*. Libraire Armand Colin, Paris.

Darby, H.C. 1956. The clearing of the woodland in Europe. In *Man's Role in Changing the Face of the Earth*, ed. W.L. Thomas. University of Chicago Press.

Dearing, J.A., Hu, Y., Doody, P., James, P.A. and Brauer, A. 2001. Preliminary reconstruction of sediment-source linkages for the past 6000 years at the Petit Lac d'Annecy, France based on mineral magnetic data, *Journal of Paleolimnology* 25, 245–258.

D'Helens, A. 1996. *Les anciens poids et mesures des Provinces de la Haute-Savoie*. Haute Savoie Conseil General.

Foster, D.R., Aber, J.D., Melillo, J.M., Bowden, R.D. and Bazzaz, F.A. 1997. Forest response to Disturbance and Anthropogenic Stress, *BioScience* 47: 437–445

Foster, D.R., Motzkin, G. and Slater, B. 1998. Land-Use History as Long-Term Broad-Scale Disturbance: Regional Forest dynamics in Central New England, *Ecosystems* 1: 96–119.

Foster, D.R. and O'Keefe, J.F. 2000. *New England Forests Through Time*, Harvard University Press.

Foster, G. C., Dearing, J.A., Jones, R.T., Crook, D.C., Siddle, D.S., Appleby, P.G., Thompson, R., Nicholson, J. and Loizeaux, J-L (in press). Meteorological and land use controls on geomorphic and fluvial processes in the pre-Alpine environment: an integrated lake-catchment study at the Petit Lac d'Annecy, *Hydrological Processes*.

Glacken, C.J. 1967. *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century,* University of California Press, Berkeley.

Grove, J.M. 1966. *The Little Ice Age in the Massif of Mont Blanc*, Institute of British Geographers, Transactions and Papers, No. 40.

Guidoboni, E. 1998. The lower Po Plain in the 16th century, *Environment and History* 4: 279–308.

Higgitt, S.R., Oldfield, F., and Appleby, P.G. 1991. The record of land use change and soil erosion in the late Holocene sediments of the Petit Lac d'Annecy, eastern France. *The Holocene* 1: 14–18.

Houghton, J.T. (ed.) 2001. *Climate Change 2001: The Scientific basis*, Cambridge University Press.

Ives, J.D. and Messerli, B. 1989: *The Himalayan Dilemma: Reconciling Development and Conservation,* Routledge, London.

Ives, J.D. and Pitt, D.C. 1988: *Deforestation: Social Dynamics in Watersheds and Mountain Ecosystems*, Routledge, London.

Le Roy Ladurie, E. 1971. *Times of Feast, Times of Famine: A History of Climate since the Year 1000,* George Allen & Unwin Limited, London.

Mahapatra, R. 2001. Betrayed. *Down to Earth* 9, No 22, 15 April 2001.

Mather, A.S. and Fairbairn, J. 2000: From Floods to Reforestation: The Forest Transition in Switzerland. *Environment and History* 6: 399–421.

Montmayeur, J.B.L. 1865. *Savoie et Savoyard: Notes de Statistique agricole,* Charles Ducrey.

Mougin, P. 1914. *Torrents de Savoie*, Grenoble.

Nicolas, J. 1978. *La Savoie au 18e siècle Noblesse et Bourgeoisie Tome II inflexions Au siècle des lumières*, Librairie de la Nouvelle Faculté – Paris.

Noël, H., Garbolino, E., Brauer, A., Lallier-Vergès, E., Beaulieu, J-L. and Disnar, J-R. 2001. Human impact and soil erosion since ca. 5000 years attested by the study of the sedimentary organic content, Lac d'Annecy, the French Alps. *Journal of Paleolimnology* 25, 2: 229–244.

Pfister, C. 1993. *Historical Weather Indices from Switzerland.* IGBP PAGES/World Data Center-A for Paleoclimatology Data Contribution Series # 93–027. NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.

Privat, É. 1973. *Histoire de la Savoie*, Toulouse, Univers de la France et des pays francophones.

Radkau, J. 1996. Wood and Forestry in German History: In Quest of an Environmental Approach. *Environment and History*, 2: 63–76.
Sclafert, Th. 1933. A propos du déboisement des Alpes du Sud, *Annales de Géographie* 42: 266–360.
Serand, F. 1935. Les derniers ours dans les montagnes de Doussard et de Faverges, *Revue Savoisienne*: 71–121.
Siddle, D.J. 1997. Migration as a strategy of accumulation: social and economic change in eighteenth-century Savoy. *The Economic History Review* 1: 1–20
Slicher Van Bath, B.H. 1963. *The Agrarian History of Western Europe A.D. 500–1850*. London, Edward Arnold (Publishers) Ltd.
Steel, E.A. 1981. Spatial dimensions of social and economic change in the peasant community, Unpublished Ph.D. thesis, University of Liverpool.
Tissot, E. 1887. Résumé des observations méteorologiques d'Annecy et de la Haute Savoie faite en 1885, *Revue Savoisienne 28e*, IIe Serie, Vol III, p2–7.
Tochon, P. 1871. *Histoire de l'Agriculture en Savoie depuis les temps les plus reculés jusqu'ànos jours*, Chambery 262 pgs.
Vayssiere, B. 1981. *Le Cadastre Sarde de 1730 en Savoie*, Musée Savoisien.
Williams, M. 2000. Dark ages and dark areas: global deforestation in the deep past. *Journal of Historical Geography* 26, 1: 28–46.