measures the present rate of expansion of the Universe.

The chance of a quasar and a foreground galaxy being aligned within the gravitational-lens critical angle (about 1 arcsecond for a galaxy like ours) is reasonably good: out to a redshift of 1 there are over 50,000 galaxies per square degree (redshift, the functional increase in wavelength of emitted light, is used as a measure of astronomical distance). The rarity of strongly lensed background quasars, with redshifts typically of 2, is due mostly to the scarcity of quasars compared with galaxies.

But lensed quasars could be just the brightest examples of gravitational lensing to be found. At the limit of detection, the sky is covered with a veil of nearly overlapping faint galaxies: there are over 150,000 galaxies per square degree that are brighter than 27 magnitude (see figure). Compared with quasar lenses, the probability of galaxy-galaxy lensing is very high. Recently, the stretched images of background galaxies have been found encircling rich galaxy clusters in the foreground^{10,11}, confirming the enormous dark

matter content of galaxy clusters.

The nature of dark matter will be revealed in the way it clumps and prospects are good for a direct measure of the dark-matter distribution. Research in galaxy-galaxy lensing is yielding constraints on the size of galactic dark-matter halos¹² and searches for totally dark gravitational lenses may show how and where dark matter clumps. □

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Ecology

The dam busters

Peter D. Moore

THE recent conclusion by Blake and Rowland¹ that the concentration of methane in the troposphere has risen by 11 per cent in the past 9 years, and the proposal of Pearman and Fraser² that levels have doubled in the past century, are timely reminders of the importance of this gas in the atmosphere. Its potential contribution to the greenhouse effect is currently a cause for concern.

How much of this methane production can be blamed on human activities (through livestock, rice paddies and fossil carbon combustion) is still in dispute and is likely to remain so until more is known about natural sources. Among these, wetlands seem to be of particular importance³. Anoxic conditions are necessary for methane production, so streams and fast-moving rivers are not rich sources, but if a stream becomes blocked and organic sediments accumulate in the resulting body of water, methane can be produced. This consideration has led Ford and Naiman⁴ to examine the role of the beaver (*Castor canadensis*) in methane generation within the boreal forests of Canada, as beavers are known to have a considerable influence on stream hydrology.

Naiman and Melillo⁵ have already demonstrated the extent of the impact of beavers on Canadian forests and their streams, suggesting that between 20 and 40 per cent of second- to fifth-order

streams are affected by beaver activity. They selected sites along tributaries of the St Lawrence River in Quebec for detailed study, some situated at points blocked by beaver dams and others in faster-moving stream sections. Floating gas samplers (inverted glass carboys) were set up at each of 10 sampling stations and aliquots were removed weekly. Methane concen-

tration was determined using gas chromatography. It was impossible to continue measurements following ice establishment, but rates of methane production dropped to 20 per cent of their former values when ice first formed, so this figure was used in order to estimate winter methane flux.

It turns out that the rates of methane production vary considerably from site to site, depending on such factors as temper-

ature and water depth. Values from beaver ponds were up to 33 times higher than those from neighbouring streams with faster flow. Add to this the fact that the area of water surface is on average seven times greater per unit stream length when dammed by beavers, and that up to 40 per cent of streams may be thus affected, and the influence of the beaver on the biome begins to look serious. Excluding natural lakes and peatlands, Ford and Naiman calculate that the beaver is responsible for 92 per cent of the methane production from the river catchments studied, and is a significant influence on an important biogeochemical cycle. It is tempting to wonder whether the beaver is aware that the greenhouse effect will reduce the global demand for fur coats.

But before beginning on a campaign of beaver dam destruction, it is worth looking to see whether there is a natural biological control agent. A contender for this role, according to the work of Reid *et al.*⁶, is the river otter (*Lutra canadensis*), which can enter beaver ponds under the ice in winter by cutting its way through the dams and leaving leaking channels in its wake. These authors suspected that the otter was behaving in this way because of the sizes of the passages in dams and the toothmarks on exposed sticks. They confirmed the passage of otters through beaver dams by tracking them with implanted radio transmitters. The beavers do not begin to repair their dam structures until the ice melts in the spring. Meanwhile, the water levels of the beaver ponds are lowered.

It seems likely that the activity of beavers in creating ponds is raising the carrying capacity of the habitat for otters by enhancing the supplies of fish in winter. But whether the otter is having a marked influence on methane generation is doubtful. In the first place, the dam-busting takes place in winter when methane production is low, and secondly the work of Ford and Naiman suggests that shallower pools have a higher rate of methane production than deep pools. But compared with the world's rice paddies and cattle rumens, not to mention the recently discussed fossil fuel sources⁷, it is doubtful whether the beaver yet constitutes a threat to our climate. □

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