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DEPARTMENT OF INDUSTRY AND COMMERCE, METEOROLOGICAL SERVICE
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SMOKE SOURCES AND VISIBILITY FORECASTING IN GREAT BRITAIN AND IRELAND

BY

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SMOKE SOURCES AND VISIBILITY FORECASTING IN GREAT BRITAIN AND IRELAND*

By

H. H. LAMB, B.A.

Domestic fires and house chimneys are the most prolific source of the smoke which pollutes the atmosphere over the British Isles and North-West Europe, and far outweigh in importance the chimney stacks of industrial plants. This is a fact which is easily verified by observation from the air over any industrial region. The smokiness of the older parts of Edinburgh, where the smoky Scottish coal is burnt in the numerous fires of many-storeyed tenements, is well known and affectionately commemorated in the name "Auld Reekie". In Dublin the same thing may be seen by a careful observer scanning the city from the Wicklow Hills or Howth. And so on in most other cities, for factory chimneys are comparatively few and far between, whilst domestic chimneys are many; and the industrial furnaces burn their fuel more efficiently than the ordinary household hearth.

The effectiveness of these sources varies according to the meteorological factors of wind speed and lapse-rate, which determine the dispersal of the smoke in the horizontal and vertical directions. With ground inversions in winter the major smoke sources in Great Britain will give visibilities of $\frac{1}{2}$ mile or less for more than 50 miles to leeward, whilst visibility may be reduced to 1—2 miles at points 100—150 miles away. These figures apply to the complex smoke sources in the London, Lancashire—West Riding and Glasgow—Lowland regions. Exceptional wind strength or convectional turbulence are required for visibilities of 10—20 miles to be observed in Eastern England.

Under favourable conditions an observer on high ground or in the air may follow a distinct smoke trail over great distances. From Aberdour or Burntisland on the north shore of the Firth of Forth, with the common easterly and east-north-easterly winds in the firth, one may watch the Edinburgh smoke trail day after day and see how it spreads to leeward in a gradually mounting wedge, enveloping all the low ground, and eventually reaches up to the cloud-base. In stable air and with stratus cloud types the wedge is very flat and the smoke is held low for many miles; on bright afternoons the smoke is much more turbulent and rises rather rapidly to the cloud-base, the distinct smoke trail being the more quickly lost to leeward for that. From the Ochil Hills between Dollar and Stirling both the Edinburgh and Glasgow smoke trails may be seen on occasion; the latter is thrown into clear relief by winter sunsets in clear northerly weather, when the smoke may appear in colours from blue to russet brown like the trail of a vast bonfire. On one occasion in the summer of 1938 the writer was able to follow in an aeroplane the distinct smoke trail from Glasgow and Clydeside through the Lowland Valley on a westerly wind to the Firth of Forth, where smoke from Edinburgh, Leith and the Fife coalfield merged in it, out over the North Sea where it was soon caught in the sea breeze circulation of the east coast and, performing a wide sweep, came back to the coast again as a thick haze, brown in the afternoon sunlight, between Montrose and Aberdeen.

This case illustrates amongst other things the complication that arises when two or three smoke sources of different orders come in the track of the same air. In England the pattern of smoke trails is specially complicated because of the number of separate smoke sources operative. In Scotland and Ireland the individual trails are usually distinct. The mountains of Scotland and Wales have the effect of deflecting the wind and confining the smoke from the towns to windward into certain channels; and when the air is not too stably stratified, these mountains so disturb the air blowing over them that the smoke is "churned up" and so dispersed as to be noticeable only as a slight haze reaching to considerable height at places to leeward.

Warm fronts and occlusions have the usual effect of trapping smoke in the pre-frontal airmass beneath the frontal surface, which closes down to give very poor visibility just before the passage of the front. The writer remembers watching an interesting case, in November, 1939, of the combined effect of the smoke of Dublin city and a small frontal wave-depression passing at no great distance to the south. At Clondalkin, which is about ten miles southwest of the city, the wind was easterly in the forenoon and backed through NE and N to NW, as the depression passed; at no time was the strength of the breeze more than 5 to 10 m.p.h., and it showed some convergence towards the front. Cloud was low (Nimbostratus) and covered the hills at about 500 feet above sea level until the depression had passed away to the east. Drizzle brought the visibility down to 1—2 miles. This was the visibility all forenoon, but as the wind backed to NE about mid-day and fell very light, bringing a dense concentration of Dublin smoke directly to Clondalkin, visibility at the ground fell gradually to less than 250 yards: so it remained for just twenty minutes, by which time the breeze had become northerly and a rapid improvement of visibility set in with the smoke-free air.

Most Dublin smoke fogs seem to be confined to

*Received on 20th January 1942; originally issued as Technical Note No. 3 of the Meteorological Service on 14th January, 1944; now published as Geophysical Publication, Vol. III, No. 2.

the Liffey Valley, the city itself and the inshore portions of Dublin Bay, this being the normal drainage channel of radiation-cooled air. On the other hand with south-easterly wind and pre-warmfrontal conditions, the smoke trail may be followed as a belt of dense haze from Dublin at least as far as Mullingar in central Ireland. And under the same conditions the observing station at Malin Head, Co. Donegal is plainly affected by smoke from Belfast and the other northern towns.

The extent of smoke pollution naturally depends also on the amount of smoke emitted. This amount is greatest soon after the fires are lit. In the Glasgow district there seems to be a climax of smokiness about 9 or 10 o'clock in the forenoon, and probably the same occurs in the other smoke sources. Districts to leeward get their minimum visibility some time later according to the length of time it takes the smoke to travel on the wind. The amount of smoke put forth is greater in winter than in summer. It increases further in cold spells: in the exceptionally cold January of 1940 the soot deposits measured in central Dublin grew at twice the rate observed in the other months of the same winter. The smoke emission must also depend on the type of fuel and the hearths in which it is burnt.

With these variable factors in mind, we may legitimately use a population map as an index of smoke pollution. This is the principle of the chart of smoke sources shown here, which is based upon the Population Charts included in the Oxford Advanced Atlas, 6th Edition, published by the Oxford University Press. The black areas, being those with over 500 people to the square mile, constitute the major sources. At the same time the more extensive areas with a population between 250 and 500 to the square mile are shown as subsidiary sources of pollution.

Such a chart when permanently displayed in the forecast room has been found to have a considerable value for the forecaster, as an aid both in the forecasting of visibility for landing purposes at other aerodromes in Great Britain and Ireland and in the interpretation of the visibility observations reported by stations.

Addendum*.

The ideas expressed in the foregoing paragraphs are confirmed by remarks made by Dobson and Meetham in a discourse at the Royal Institution on February 12th, 1943 (reported in *Nature*, March 20th, 1943), quoting results of observations made at certain English towns for the Department of Scientific and Industrial Research.

Observations at Leicester show a diurnal variation of atmospheric cleanliness corresponding inversely to the periods of greatest domestic fuel consumption, whilst the falling off of pollution on Sundays is slight enough to prompt the comment that " . .at a very rough estimate . . . . . the smoke pollution is two-third domestic and one-third industrial in origin." Observations at Oxford of the arrival of smoke from the Midland towns, bringing decreasing visibility about noon with light or moderate northwesterly winds, illustrate the time-lag in the onset of poor visibility at points to leeward of the smoke-source. Dobson and Meetham confirm that the maximum of atmospheric obscurity in the region of the smoke source is in the forenoon, and their observations reveal a second maximum about the time of cooking the evening meal.

*Added 12th April, 1943.

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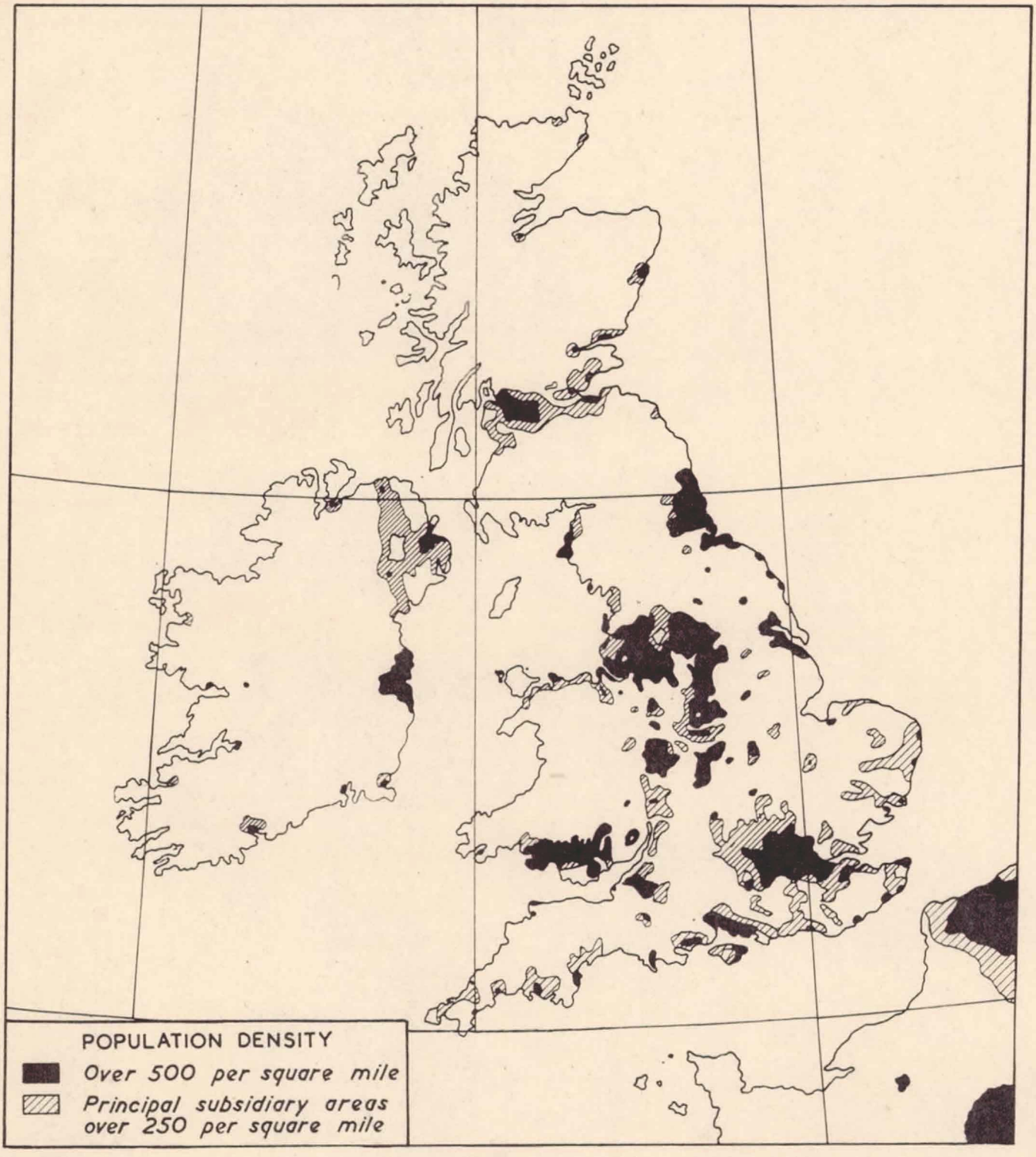

Fig. 1. SMOKE SOURCES IN GREAT BRITAIN AND IRELAND

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