NOTE ON THE OCCURRENCE OF A LIMESTONE-FLORA AT GROSE VALE.

By W. M. Carne.

Instances of the part played by geological formation in the distribution of species and the formation of plant-communities in New South Wales, have been put forward from time to time, by various botanical and other workers. So far as the writer is aware, no record has yet been published dealing with the effect of a lime-deposit on vegetation.

The present note deals with an interesting, though small, patch of vegetation occurring on an outcrop of a limestone at Grose Vale, Hawkesbury District. The deposit is to be found below Box Hill, and is followed by the Horseshoe Bend Road, which, running N.E. and S.W., joins the main Kurrajong and Grose Vale Roads. It is on the eastern slope of the hill, which curves to form a natural amphitheatre sheltering orchards and other cultivated areas. At about 100 yards from the Grose Vale end, and following the road for about half a mile, nearly to what is known as Lookout Hill, is the outcrop, with its vegetation, which is so distinct as to be noticeable against the hillside from several miles away. Another small deposit, denuded of timber, occurs near the church, about half a mile from Kurrajong Road. The deposit is about 800 feet above sea-level, and about 8 miles by road from Richmond.

The dense growth of trees, entangled with many creepers, and the absence of Eucalypts, resembles that of the luxuriant gully-brushes of the eastern slopes of Kurrajong Range; or, perhaps, more nearly, those on volcanic soils, such as at Mountain Lagoon, Mount Wilson, or even of the Illawarra slopes. Above the road, this vegetation extends nowhere more than 20 yards, while, on the steep slope below, its width has been much greater, probably owing to the soil having been washed down from the outcrop

above. Much of the lower portion has, however, been cleared, and only a few patches remain to indicate the once luxuriant nature of the flora.

The soil, in colour, is a brownish-white, and of a loose granular texture. Where the rock is exposed, it is not unlike basalt, and as such it is locally taken to be, a mistake probably influenced, to some extent, by the vegetation. Where it is weathered, it resembles a very soft sandstone. Mr. H. G. Smith* has recorded deposits of similar limestone from Auburn and from Homebush. Like that at Grose Vale, they occur as deposits in the Wianamatta Shales. Mr. Smith informs me that the Grose Vale rock contains more sand than the two deposits mentioned, but is almost identical with that found near Lakemba, on the railway between Belmore and Bankstown. Not being naturally exposed, no botanical indications of these deposits were noted by him. Referring to the Auburn deposit, he says: "When first broken, it is of a blue-grey colour, not much unlike basalt; it was spoken of as 'blue metal' by the quarrymen, who no doubt consider it identical with the igneous rock bearing the same name. On weathering, the limestone becomes lighter grey in colour." In all these deposits no sign of organic structure can be detected under the microscope. Mr. Smith classes them as hydraulic limestones. The normal soil of the Vale is that of the Wianamatta Shales, with the usual flora of stringybarks, ironbarks, red gum, blackthorn, etc.

The explanation of this very distinct and localised plant-community seems to be due to (1) the richness of the soil due to the relatively large amount of lime present, with its accompanying greater availability of plant-foods, and its improved physical nature; (2) the sheltered eastern aspect; and (3) the good rainfall.

The following is Mr. Smith's analysis of the Auburn rock :—

$CaCO_3$	=39·673%	$MnCO_3$	=0·425%
Clay	=39·416%	$MgCO_3$	=1·625%
Fe_2O_3	= 2·686%	Alkalies present as chlorides	=0·679%
$FeCO_3$	=13·480%	Water	=2·260%

* Smith, H. G., "Preliminary Note on Limestone occurring near Sydney." Journ. Proc. Roy. Soc. New South Wales, xxvi., 1892, p. 302.

An average sample of the soil at Grose Vale has been found, by Mr. M. S. Benjamin, Assistant Chemist, Hawkesbury Agricultural College, to contain 4·23% of lime. The litmus reaction is faintly alkaline. Round the outcrop, owing to the intermingling of the shale with the limestone, and the leaching of the latter, the amount of lime is much smaller, less than 0·5%. Here the two floras tend to mingle to some extent, although the boundaries of the two are remarkably distinct. Here, too, are found some plants, marked (‡) in the accompanying list, which, while not occurring on the limestone proper, are hardly typical of the Wianamatta proper. These may be almost classed as an intermediate flora. It may be mentioned that Wianamatta soils give a strongly acid litmus reaction, and an average analysis of ten samples shows only 0·136% of lime.* Where, as in Australia, soils tend to be deficient in lime, the amount present is often, to a large extent, indicative of the value of the soil to plants.† It is recognised in agriculture that the value of lime in a soil lies, not so much in itself directly, as in the part it plays in encouraging bacterial action, in rendering soil-foods available to plants, and in improving the texture of the soil. The chief cause of the luxuriant brush-like vegetation under consideration is the rich open soil, resulting from the presence of an unusual amount of lime. The difference in the vegetation on acid and basic granites, as pointed out by Mr. Cambage and others, is due to the same reason, for "acid granites low in lime-minerals yield poor soils; basic granites fairly well supplied with lime-minerals yield good soils."‡ "Although the characteristics of the lime-flora are clear and distinct, yet, in the past, the influence of lime upon vegetation has been overestimated. Indeed, a distinction has been made between calciphilous and calciphobous plants. Recently it has been definitely established that the amount of lime, in

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*Jensen, H. I., Agric. Gazette of New South Wales, 1910, p.463.

†Guthrie, F. B., Agric. Gazette of New South Wales, 1898, p.484; and Jensen, H. I., *op. cit.* 1909, p.1091.

‡Jensen, H. I., Agric. Gazette of New South Wales, 1910, p.105.

itself, in so far as it does not operate physically, cannot be the cause of differences in the flora, for not only can calcicolous plants be cultivated in soil that is poor in lime, but silicicolous plants, and even bog mosses, which are regarded as pre-eminently calciphobous, can grow vigorously in pure lime-water, if the aqueous solution be otherwise poor in dissolved salts. It has been overlooked that nearly all lime-soils are rich in soluble mineral substances, and this wealth excludes plants belonging to poorer soils; beyond this, the important physical characters of calcareous soils come into play."‖

As to where the plants forming this flora came from, it seems sufficient to regard them, like the plants of the Blue Mountain gullies, as remnants of the old tropical flora, which at one time extended as far south as Victoria. Superior conditions in circumscribed localities have enabled these remnants to persist, while the rest of the country has become occupied by the present, dominant, hardy flora which the drier conditions of to-day have evolved.

The rainfall is good, about 33 inches.¶ Kurrajong Heights, three miles away, and 1,000 feet higher, averages 50 inches per annum. The moisture-capacity of the soil is equal to that of the shale, but its capillarity is much greater. The loss of water by evaporation must, however, have been largely checked, before any clearing had been carried out, by the dense shading of the soil. The area certainly gains moisture by soakage from the steep slopes above. The road remains moist after rain, long

‖ Warming, E., "Ecology of Plants." 1909, p.58.

¶ Of late years there has been a general diminution of rainfall in this district (see Bulletin No.2, Commonwealth Bureau of Meteorology, 1908).

For the following figures I am indebted to Mr. W. S. Arnold, who lives not far from the limestone-outcrop.

	1903.	1904.	1905.	1906.	1907.	1908.	1909.	
	42·24	37·96	26·18	25·17	21·35	29·48	25·98	
Compare Richmond	33·32	33·95	22·84	17·17	17·77	25·06	23·07	Average, 29 years = 29·90

after the soil-surface of the shale round about has dried up. On drying, instead of caking, the soil becomes loose and open. Moisture is thus readily absorbed, instead of running off down the steep slopes. Severe frosts are unknown.

As the outcrop occurs inside the amphitheatre, and some way down the hill-side, the aspect, facing the morning sun, and sheltered from the westerly winds, is almost an ideal one. These matters of aspect and rainfall are almost sufficient, in themselves, to bring into existence the well-known vegetation of Sassafras, Coachwood, Myrtles, Tree-ferns, etc., typical of the gullies of the eastern slopes of the Kurrajong, had there been sheltered gullies. But the position is too exposed, and the vegetation quite distinct. It is not confined to such small gullies as there are, but climbs up their sides and spreads along the hill-slopes.

In the following list, those plants marked * are believed to owe their position to the favourable conditions offered by the limestone-soil. Many of these plants are admittedly found on sandstone country, but they are not typical of that soil; and the explanation of their presence is probably to be found in the favourable local conditions. Mr. Hamilton§ shows, that at Mt. Wilson, most of these plants prefer the basalt to the sandstone.

I have to thank Messrs. J. H. Maiden and C. T. Musson for assistance in the preparation of this note.

Ranunculaceæ	... *Clematis aristata* R.Br.
	glycinoides DC.
Magnoliaceæ	...**Drimys dipetala* F.v.M.
Anonaceæ ...	.. **Eupomatia laurina* R.Br.
Menispermaceæ	...**Cocculus Moorei* F.v.M.
	**Sarcopetalum Harveyanum* F.v.M.
Cruciferæ ...	... *Lepidium ruderale* L.
Pittosporeæ	...**Hymenosporum flavum* F.v.M.
	Bursaria spinosa Cav.
	**Citriobatus multiflorus* A. Cunn.

§ Proc. Linn. Soc. N. S. Wales, 1899, p.346.

*Found on the limestone. †Introduced weeds. ‡Intermediate flora (p.851.)

Malvaceæ ...	... *Sida rhombifolia* L.
	Abutilon oxycarpum F.v.M.
	**Hibiscus heterophyllus* Vent.
	†*Modiola multifida* Moench.
Sterculiaceæ	...‡*Sterculia diversifolia* G. Don.
Lineæ	...†*Linum gallicum* L.
Geraniaceæ	... *Geranium pilosum* Sol.
Rutaceæ ...	...‡*Evodia micrococca* F.v.M.
	**Acronychia Baueri* Schott.
Meliaceæ ...	...**Melia composita* Willd.
	**Cedrela toona* Roxb.
Celastrineæ	...**Elaeodendron australe* F.v.M.
Rhamneæ ...	...**Alphitonia excelsa* Reiss.
Ampelideæ .	...**Vitis antarctica* Benth.
	* *clematidea* F.v.M.
	* *hypoglauca* F.v.M.
Sapindaceæ	...**Cupania semiglauca* F.v.M.
	**Nephelium leiocarpum* F.v.M.
	Dodonaea viscosa L.
Leguminosæ	... *Indigofera australis* Willd.
	Desmodium brachypodium A. Gray.
	Glycine clandestina Wendl.
	†*Medicago minima* Willd.
	† *denticulata* Willd.
	†*Vicia hirsuta* Koch.
	**Cassia laevigata* Willd.
	* *australis* Sims.
	Acacia longifolia Willd.
	decurrens Willd.
	†*Trifolium repens* L.
	† *dubium* Sibth.
Rosaceæ ...	... *Rubus parvifolius* L.
	* *moluccanus* L.
	Acaena ovina Cunn.
	sanguisorbæ Vahl.
	†*Rosa rubiginosa* L.

SAXIFRAGEÆ	...‡*Aphanopetalum resinosum* Endl.
	**Cuttsia viburnea* F.v.M.
MYRTACEÆ ...	.. *Callistemon salignus* DC.
	Melaleuca styphelioides Sm.
	Eucalyptus hemiphloia F.v.M.
	tereticornis Sm.
	**Rhodamnia trinervia* Bl.
	**Eugenia Smithii* Poir.
ONAGRARIEÆ	... *Epilobium glabellum* Forst.
	†*Oenothera rosea* Willd.
	† *tetraptera* Cav.
PASSIFLOREÆ	...**Passiflora aurantia* Forst.
UMBELLIFERÆ	... *Apium leptophyllum* F v.M.
	Daucus brachiatus Sieb.
CAPRIFOLIACEÆ	...**Sambucus xanthocarpa* F.v.M.
COMPOSITÆ ...	... *Vittadinia australis* A. Rich,
	var. *tenuissima*.
	Calotis lappulacea Benth.
	†*Xanthium spinosum* L.
	Siegesbeckia orientalis L.
	Bidens pilosus L.
	†*Tagetes glandulifera* Schrank.
	Helichrysum diosmifolium Don.
	Erechtites arguta DC.
	†*Carduus lanceolata* L.
	†*Sonchus oleraceus* L.
CAMPANULACEÆ	... *Wahlenbergia gracilis* DC.
	Lobelia purpurascens R.Br.
EPACRIDEÆ ...	... *Leucopogon juniperinus* R.Br.
PRIMULACEÆ	...†*Anagallis arvensis* L.(red and blue varieties)
MYRSINEÆ ...	..‡*Rapanea* (*Myrsine*) *variabilis* Mez.
EBENACEÆ ...	...**Cargillia australis* R.Br.
JASMINEÆ ...	... *Notelaea longifolia* Vent.
ASCLEPIADEÆ	...**Marsdenia rostrata* R.Br.
	†*Gomphocarpus fruticosus* R.Br.
GENTIANEÆ	... *Erythraea australis* R.Br.

Asperifoliæ	...**Ehretia acuminata* R.Br.
Convolvulaceæ	... *Dichondra repens* Forst.
Solaneæ ...	... *Solanum nigrum* L.
	† *pseudo-capsicum* L.
	stelligerum Sm.
	xanthocarpum Schrad.
	†*Physalis peruviana* L.
	Nicotiana suaveolens Lehm.
Bignoniaceæ	...‡*Tecoma australis* R.Br.
Acanthaceæ	... *Eranthemum variabile* R.Br.
Myoporineæ	... *Myoporum debile* R.Br.
Verbenaceæ	.. †*Verbena bonariensis* L.
	† *venosa* G. & H.
	‡*Clerodendron tomentosum* R.Br.
Labiateæ ...	... *Plectranthus parviflorus* Willd.
	Mentha gracilis R.Br.
Plantagineæ	... *Plantago varia* R.Br.
	† *lanceolata* L.
Phytolaccaceæ	...†*Phytolacca octandra* L.
Chenopodiaceæ	... *Chenopodium triangulare* R.Br.
	† *ambrosioides* L.
Amarantaceæ	... *Nyssanthes erecta* R.Br.
Polygonaceæ	... *Rumex Brownii* Campd.
	†*Polygonum convolvulus* L.
Laurineæ ...	...**Endiandra*(?).
	**Litsea dealbata* Nees.
Euphorbiaceæ	.. ‡*Phyllanthus Ferdinandi* J. Muell.
	‡ *Gastroemii* J. Muell.
	‡*Breynia oblongifolia* J. Muell.
	‡*Croton Verreauxii* Baill.
	**Carumbium populifolium* Reinw.
Urticaceæ ...	... *Urtica incisa* Poir.
	‡*Trema aspera* Bl.
	**Ficus stephanocarpa* Warb.
	**Cudrania javanensis* Trecul.

Santalaceæ	...**Santalum obtusifolium* R.Br.
	Exocarpus cupressiformis Labill.
Irideæ	...**Sisyrinchium paniculatum* Spreng.
Liliaceæ ...	... *Smilax australis* R.Br.
	Dianella longifolia R.Br.
	Eustrephus latifolius R.Br.
	Geitonoplesium cymosum A. Cunn.
	Xerotes longifolia R.Br.
Commelynaceæ	... *Commelyna cyanea* R.Br.
Juncaceæ ...	... *Juncus polyanthemus* F. Buch.
Cyperaceæ ..	... *Gahnia melanocarpa* R.Br.
	aspera Spreng.
	Carex longifolia R.Br.
	appressa R.Br.
Gramineæ ...	... *Panicum pygmæum* R.Br.
	Oplismenus setarius Roem. & Schult.
	**Cenchrus australis* R.Br.
	Andropogon sericeus R.Br.
	pertusus Willd.
	refractus R.Br.
	Microlaena stipoides R.Br.
	Aristida vagans Cav.
	Stipa verticillata Nees.
	pubescens R.Br.
	Dichelachne sciurea Hook.
	Danthonia pilosa R.Br.
	Echinopogon ovatus Palis.
	Cynodon dactylon L. C. Rich.
	Leptochloa decipiens Stapf.
	Sporobolus indicus R.Br.
	Lindleyi Benth.
	Eragrostis leptostachya Steud.
	†*Briza maxima* L.
	† *minor* L.
	†*Festuca bromoides* L.
	†*Hordeum murinum* Caesalp.

Filices	...	...**Adiantum formosum* R.Br.
		**Adiantum affine* Willd.
		**Pellaea falcata* Fic.
		**Doodia aspera* R.Br.

Total 57 families, 130 genera, and 156 species. It is remarkable how few genera are represented by more than one species.

There is no doubt that, even up to recent years, this flora covered an area much larger than it does to-day. Many roadside plants, both native and introduced, have established themselves. Clearing is still going on. The conditions for luxuriant growth are no longer so favourable, and in a few years this interesting patch of vegetation will probably disappear.