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WIND EFFECTS

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THE following study is the outcome of attempts to improve the teaching of climates by basing climatic features more and more on weather or other concrete phenomena. We may regard climate as ideal and weather as concrete, just as spheres are ideal and balls are concrete. In teaching geometry, a good deal of difficulty arises from lack of specific effort on the teacher's part to help the beginner's mind to the ideal and abstract conceptions dealt with. And climate, as taught in many schools, amounts to little more than words to be memorized, because of utter lack of grounding in the real. The facts of the weather are real, concrete, and observable everywhere. If these facts are observed and studied, the features may be learned that characterize our climate. The drawing of inferences from the facts, however, involves mental processes in which the beginner needs training. The reasoning process should carry conviction. How often we hear a young thinker say, "Yes; I see that; but it does not seem as if it could be so." Familiarity with the inductive method is needed to give faith in it, and there is especial need of every possible test of the results. For this reason it is desirable to come to our conclusions by as many roads as we can find.

Supposing it is desired to get the student to believe in our westerly winds as an important climatic feature. We may work along three lines:

1. Observe the weather vane and after some months find which wind has blown oftenest.
2. Study the weather map and make out on it the procession of highs and lows to eastward.
3. Look at the trees that have grown exposed to the force of the winds for indication of thrust in one direction rather than in others.

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FIG. 1. *Yellow birch on west slope of Grant Hill, Gilmanton, N. H., looking north by east.*

FIG. 2. *Laurel near Cabañas fortress, Havana, looking west.*

Of the two pictures given, the first is a yellow birch in the Belknap Mountains in New Hampshire. The trunk is a little inclined to the west, owing to the common gravitative creep of the soil downhill, but the growth of the branches suggests a strong eastward movement of the air, although there was no wind at the time of the exposure. The whole tree makes one think of the hill as a wind-swept height. Such trees are not infrequently represented from mountains.* One thinks of westerly storms as driving these trees out of shape. So of

FIG. 3. Laurel, Central Park, Havana, looking west.

the windward side of the volcanic Caribbees, Hill says, "The trade wind sweeps them with such ferocity that the vegetation all bends in a cringing position towards the land."†

The laurel of the second view stands over the road from Cabañas fortress. There is no especial reason for speaking of violent winds here. The tree is near sea level, though exposed to the trade winds heightened in the daytime by the heating of the land. The "ferocity" of the trades, in Mr. Hill's language, is suggested rather by the striking effect than by the winds themselves. The trades are strong rather than violent. From this same point, by the entrance to Havana harbor, an avenue called the Prado leads off a little west of south, and down

* Chun, *Aus den Tiefen des Weltmeers*, p. 160. The pines near Cape Town.

† Hill, *Cuba, Porto Rico, etc.*, p. 328.

this again are seen many notable examples of the one-sided growth of the vegetation. This is well shown in the laurels and framboyanes of the Central Park at the end of the Prado. Figure 3 is typical.

But continuity of direction in even moderate winds leaves record as definite and unmistakable as mountain storms. Our prevalent westerly winds are recorded in the growth of the maples from New England to Michigan. When the tree is in leaf the result is a one-sided growth, well displayed in Figure 4, while in the twig the effect is still clearer, as in the absolutely typical example from Ypsilanti, Figure 5.

About Ypsilanti the white poplar points its branches in unison down the wind, as does a fine example of the same tree in the Boston Public Garden. Figure 6 is a poplar at Ypsilanti.

FIG. 5. *Maple at Ypsilanti, looking north.*

The distinction between constant and prevalent winds enters largely into the difference between the climates of the trades and westerly wind belts, which between them occupy the greater portion of the earth. In the trades are clear skies, even temperatures, and winds always in the same quarter, rising and falling with some swing in

FIG. 6. *White poplar, Ypsilanti, looking north.*

direction at the shore; in the westerlies, spells of fine and spells of stormy weather, with winds veering and backing through all the points of the compass. To teach this properly, we must begin with the westerlies about us. But the westerlies are only an average, only an excess of one wind direction over others, and a difficulty for beginners lies at this point.

Suppose that we have gathered observations like those of the accompanying table, the percentages of the whole year that the wind is in each direction, at Detroit, for instance.

DURATION OF EACH WIND DIRECTION IN PERCENTAGES OF THE WHOLE YEAR

	<i>Latitude</i>	N	NE	E	SE	S	SW	W	NW	Calm
Boston	42°	8	9	10	4	7	20	23	19	0
Detroit	42°	5	15	9	7	5	31	13	15	0
San Francisco	38°	6	4	3	8	8	38	23	9	1
Dodge City	38°	13	15	5	24	18	6	4	15	0
Key West	25°	9	22	28	22	6	5	2	6	0
Santiago, Cuba	20°	18	28	4	10	17	10	2	4	7
Santo Domingo	18°	46	9	4	18	7	2	1	11	2
San Juan, P. R.	18°	1	8	39	36	6	5	1	2	3
Barbados	13°	1	30	48	19	1	1	0	0	0
Curaçao	12°	0	9	79	11	1	0	0	0	0

That is, for 59 per cent of the time the wind at Detroit is either in the NW, W, or SW. Yet a fact that always looks very large to a beginner is that the wind is NE as often as NW, and oftener than it is west. Moreover 59 per cent is only a little more than half the time. If he has access to the other numbers, he may find some reassurance in the data for Boston and San Francisco, but he will be certain to seize on Dodge City as giving the whole case away. Here is a place in the latitude of the westerlies with more east winds than west! All that this means is that concrete details have a reality that

FIG. 7. Coconut palms at Santa Cruz, Danish West Indies, looking northwest.

is not possessed in like degree by the conclusions drawn from them. If, however, we can now confirm these conclusions in any way, we shall strengthen the reasoning process. A map of the United States on which are laid down the average directions of all the winds at all places adds definiteness here. But as the effects of an excess of one wind direction are absolutely real and definite, the evidence of the trees that have been influenced by it in their growth is of the greatest value in teaching.

Spells of cyclonic and anti-cyclonic weather should be watched as they go by, with the help of the daily weather map, though they have not for the beginner so much reality.

That *tempera'e zone* is a misnomer for the belt of westerly winds has long been known. Probably there is nothing characterizes these regions so sharply as their winds, prevailing westerly, but interrupted by winds from all other compass points in succession. Nothing will

give a better notion of trade-wind weather than an absence of these fluctuations. Figures such as those for Curaçao and Barbados in the table may be contrasted with the figures for Boston or Detroit to get this idea. It is easier to grasp the average conditions in the trades since they occur daily. The other points for which wind directions are given in the table, however, have their average less distinct. Local influences such as the direction of the coast line are plainly influential here. What approach to these facts could be more real than such pictures as Figure 7?

Where sea and land breezes alternate, the excess in strength of the sea breeze comes out well in the growth of trees along shore. In some way, it is desirable to get the picture of these effects into the pupil's mind. A need for an explanation will then arise.

All this is antipodal to the method by which climates were taught first, and the weather never reached in teaching it all. As a result, the ideal thing, climate, existed in our minds as a lot of disconnected phrases that burdened the memory and left no more definite conceptions than that the Nile rose in summer or winter—one did not certainly remember which. The naming our zone *Temperate* seems only to rest on the climatic conception of our average temperature, some 60°, which sounds mild and temperate. Yet the actual weather could hardly be less temperate, ranging through temperatures from 100° to -40°. Nowadays we like to look for vigor and bracing for deeds in these immoderate ranges. It is in the belt of westerlies, with weather in spells, that civilization is taking the greatest strides in history, and there it seems likely to make others.

Civilization began in Babylonia and Egypt, in the belt that on sea is characterized by trade winds. It failed there, to try again in Mediterranean countries, on the border of the trade and westerly belts. There, too, a few centuries of progress ended in the shock with barbarism and collapse. With the revival of learning came men who accomplished things in the belt of westerlies, and there has been more of human progress in a few hundred years than in all the long past of the race.

Spain, the land that lay across the border of the belts, lingered in power into the dawning of the new epoch. The trade winds bore Columbus to America almost irresistibly, when once his mind was made up to go. Clear skies with fair and balmy winds accompanied him all across the Atlantic. There was no obstacle to his progress but the fear of the great unknown ocean that opened out wider and

wider before them day after day. Down the coast of Africa to the Canaries and Cape Verde, and thence straight across to the Antilles, the unfailing breezes wafted hordes of Spanish conquistadores to Mexico and Peru. The return was less easy, but any Spaniard who could buy a vessel and get together a crew became at once a sea captain and made his way to the new world of gold and opportunities.

A little farther north, where the English lived, other winds blew. The Englishman that crossed the Atlantic did so in the face of violent gales. Only seamen dared repeat the trip. Presently, when the Invincible Armada appeared in the English Channel, and the English came out in their trim seafaring ships, snug and stanch and well-handled, as the Spanish ships were not and could not be, the wind had only to rise to destroy Spain's pretense at naval power forever. The English had been to the best of schools of seamanship. The Spanish had lived by a tranquil sea, with all this schooling omitted. In Asia, India has given promise, but a better fulfillment seems reserved for Japan, and, perhaps, China, in the westerlies. In the new world, too, all the early hopes were founded on the trade-wind countries in the West Indies, Mexico, and Peru. To-day's fulfillment is all beyond in the westerly belt, here in our country, in Chile, and the Argentine Republic, as in South Africa, New Zealand, and southern Australia.

The typical wind effect is not an inclination of the trunk. The willow often has its trunk inclined to the east and its western branches fairly over the base of the tree. But this may be in some part due to the softness of the wet ground that this tree affects, which may yield somewhat to the force of the wind pulling on the roots. On the St. Clair Flats, Michigan, the delta of the St. Clair River, willows have been planted along the banks of the United States ship canal, and here and there about the buildings along the banks of natural channels. These willows, by their wind effect, enable the traveler to follow the windings of the canal as readily as a compass in hand. The electric road from Port Huron to Detroit, on the land just to the west of the St. Clair River and Lake, touches at the town of Algonac on the Flats and then, to continue to Detroit, has to make a long detour to west and north. During a first trip over the line, while the motor rendered the compass useless, the growth of the Lombardy poplars along the roadside seemed unintelligible. Upon examining a map, however, it became clear that they all showed an admirable wind effect to NE. The Lombardy poplar often grows erect in the wind.

In orchards, too, the trunks are usually inclined when the ground

beneath is cultivated, so that in the Michigan Fruit Belt it is the custom to set out the trees with a lean to the southwest, that they may be straightened by the wind. Here again it is possible that the cultivation softens the ground so as to allow the inclination in question.

FIG. 8. Willow, *Ypsilanti*, looking south.

No trees in groves show really typical wind effects, since the outer trees protect those within. In dense forest growth this causes light effects to acquire especial importance. The outer trees develop strongly in every direction away from the center, and those within reach up vertically for the light, pruning away the lower branches by failing to nourish them and their leaves. The best trees to examine are those that have grown in isolated fields, or in open order along roadsides. The typical effect is a bending or inclining of the twigs to leeward, and for this reason the best season for these studies is after the fall of the leaf. When trees are leaved out the main effect is a one-sidedness of the top. Not every tree standing alone has grown alone. Southern Ontario has many single trees, elms, and others,

along the line of the Michigan Central Railroad, which seem exceptionally regular in growth. Their naturally pruned trunks and the abundant stumps about, however, indicate that these trees grew in a wood and were protected from the wind. Most trees that grow in the open branch from near the ground up, and by this they may be known.

The results of this modification of free growth are individual with each kind of tree. Cottonwoods in the country about Ypsilanti seem to grow uninfluenced by the wind, however exposed their situation. Figure 9 is a fair example. Yet all the cottonwoods in the Boston Public Garden, though less exposed to the wind than many of the trees at Ypsilanti, incline their branches off distinctly to the east. In the West Indies the royal palm stands vertical and columnar, though in this case, strangely enough, the newest leaf, rolled into a tight cane at the summit of the tree, leans slightly against the wind, as if some force that availed to keep the trunk upright against the wind-thrust, bent this tender shoot over backward. In the picture, Figure 10, the

FIG. 9. Cottonwood at west end of Cross Street bridge, Ypsilanti, looking north.

leaves are actually driven to one side by the trade wind which is blowing, and the new leaf or penacho of each tree is inclined to the northeast, from which direction the wind was blowing. This was found to be an almost invariable rule with thousands of these trees examined this

FIG. 10. *Royal palms near Cardenas, Cuba, looking northwest.*

summer in Cuba. While the cottonwood, at least about Ypsilanti, is thus resistant to wind effects, its cousin, the white poplar, shows them in a high degree. Indeed, while a careful observer has no difficulty in distinguishing the two trees, a novice would ask no better guide than the degree in which they yield to the influence of the wind.

In the poplar, curves are strongly developed. On the east side of the tree, the branches form curves concave to the ground. On the west, vertical lines would cut not a few branches in two points with the curve between concave to the east, so strongly are they bent to leeward as they grow. (See Figure 6.) In this case it is a branch effect rather than a twig effect, while the individuality of the poplar comes out in the curve. The Ypsilanti poplars show these forms, even when poorly exposed to the wind, and reference has already been made to the one in the Boston Public Garden.

The maple succeeds better in rearing its greater branches vertically into the air. There is a distinct curving here, too, in the more slender branches, but much less in degree. The maple runs to slender and hair-like twigs, and the development of the twigs is almost horizontal on the east side of the tree and vertical on the west, as if they had been combed upward on one side and outward on the other. (See Figure 5 and the tailpiece.) Maples give excellent wind effects everywhere that I have observed them. If there are any about Dodge City, Kansas, it would be of interest to know how they grow.

Elms, too, are available for observation through a wide stretch

FIG. 11. *Elm, southwest corner of Boston Common looking north across Boylston Street.*

of this country. The elm branches grow longer to eastward than to westward, which enables the slender ends to hang nearer the ground on the east. The trunk stands almost invariably to west of the mid tree-top. A fine example stands near the old burial ground on Boston Common. The twig effect on the elm is not unlike that of the maple, but the greater length of the pendulous end twigs takes away the appearance of combing upward on the west side. The tips of the lower limbs on both sides hang directly downward, but toward the

top of the tree the effects are almost identical with those observed on the maple. The crown of the elm, however, is flat. The Boston elm was photographed in September while still in leaf. Figure 12 is an example in twig. A photograph of the same tree from the west is quite symmetrical.

FIG. 12. Elm at Ypsilanti, looking north.

The oak and the hickory show the same excess in length of eastern over western branches, and the eastern ones also usually spring out more nearly horizontally. This appears very well in Figures 13 and 14, which are typical. Occasionally the oak shows a curving of its branches, but the type is stiff, crooking a little on either side of straight lines. The hickory branch is excessively crooked. Another crooked branched tree is the sycamore, or buttonwood, as shown in the tail-piece. But the crooks of the sycamore are rather in the smaller twigs, and the twigs are more of the combed type, as in the maple, having a considerable approach to parallelism, while the twigs of the hickory present a mere tangle. The wind effect on the hickory is thus a matter of one-sidedness, dependent on length of branch. In the sycamore it is equally evident in the direction of the twigs.

The black walnut also usually shows a greater development of top to leeward. A tulip tree east of the soldiers' monument in Boston

FIG. 13. *White oak at Ypsilanti, looking north.*

FIG. 14. *Hickory at Ypsilanti, looking north.*

Common shows distinct effect, apparently by curving its summit branches. But I have not observed this tree in the twig.

The cocoanut palms from Santa Cruz, Figure 7, show the wayward growth of that tree along with the influence on it of the northeast trades. I do not, of course, refer to the long fringes of these palms that are wont to line tropical shores at the top of firm beaches. There light effect causes them to reach away from the woods behind. But out in the open the tree seems to prefer to lean in its growth, quite apart from the direction of the wind. Some of the trunks have grown distinctly against it. So, with us, the box elder, for all its cousinship to

FIG. 15. *Alamos near Havana, Cuba, looking east-southeast.*

the maple, is rarely seen growing upright, wind or no wind. I know of no way of recognizing the tree so sure and simple as its habit of leaning, and neighboring specimens usually lean in different directions.

Many tropical trees resemble the maple in having their tops one-sided under wind influence, though they are one-sided to south or west instead of to east. The laurels of Figure 3 are of this type. So also the framboyan and the alamo, as in the accompanying sidewalk row, Figure 15. It must not be thought that these trees are leaning out over the street for light. There is an open yard to the northeast, and nothing to cut off light from that direction. On the opposite side of the street the trees lean in the same direction. Some of these may be seen in the picture. It is interesting to get generalized views of

FIG. 16. *Arbor vitae* at the Mausoleo, Cardenas, looking south.

this sort by standing in the middle of a street that runs north and south and looking along the street. It will be found in this country that the meeting of the branches overhead is well to east of the middle of the road. The Charles Street mall of Boston Common offers a good illustration. The Ceiba or silk cotton tree is regarded by the Cubans as their national tree. It grows alone in the plains, with trunk rising naked a considerable height to the thick top which is always strongly developed to leeward.

Our pines and spruces commonly grow in woods or clusters and so are little affected by the winds. Even in the New Hampshire hills only exceptional examples were found. Creole pines may be seen planted in the gardens about Havana showing admirable effects. The arbor vitae (thuyas) in the garden at Cardenas all lean to westward. But this garden is a new one, commemorating with its monument the dead of the recent war. So the trees have probably been planted within the last four or five years, and may have been simply pushed to one side before the roots got a firm hold on the ground. It is curious that the wind-thrust on these trees has been from the east, as in all cases near the shore at Cardenas, while the northeast side of each tree has a blighted look, as if the branches on that side had been killed by some storm from the northeast. Something of this blighted look may be seen in the picture.

In fact, both east and northeast winds prevail in northern Cuba. From an examination of the records of the United States Weather

Bureau at Havana for the years 1900, 1901, and 1902, it appears that the wind is in the east fifteen hours a day and in the northeast the rest of the time. This is true summer and winter. The seasonal differences are slight. But it appears that the greatest force is during the time that the northeast wind is blowing, so that five or six more miles of wind go by during the briefer period. It is from 11 A. M. to 7 P. M. that the Brisa blows, when the sun has heated up the ground. It is, therefore, to be regarded as a true sea breeze. Occasionally a land breeze springs up during the night. At other times it merely falls off in velocity and settles back into the east. The following table gives the data for every other hour:

AVERAGE WIND DIRECTION AND VELOCITY AT HAVANA,
1900, 1901, AND 1902

	A. M.						P. M.					
Time	1	3	5	7	9	11	1	3	5	7	9	11
Direction	E	E	E	E	E	NE	NE	NE	NE	NE	E	E
Miles per hour	7.7	7.3	7.2	7.4	10.1	13.2	15.1	16.6	15.5	12.6	10.3	8.9

FIG. 17. *White birch on the west slope of Baldface, Gifford, N. H., looking north-northwest.*

The east wind has an average velocity of 8.4 miles an hour; the northeast, 14.6. The vegetation suggests the northeast winds for most points between Havana and Cardenas, but shore places at Cardenas and Matanzas indicate easterly winds. Such studies may afford a

method of determining prevalent winds in regions meteorologically unexplored.

Light effects on tree growth are of much interest in connection with these wind studies. Trees tend to grow strongly toward the light. A singular example of an elm on the flood plain of the Huron, south of Ypsilanti, with a strong top growth to the northwest, was found to have alongside it the stump of a cut-away mate that had prevented it from developing to eastward. But more has been attributed to light effect than observation warrants. White poplars may be found close to the west of a house, but growing strongly toward it. Such observations as have been made seem to justify the statement that light usually has less effect on trees fairly exposed to the wind than the wind does. When they work in opposite directions the light effect is masked by that of the wind. It is not certain that the direct sunlight has more influence on tree growth than the diffused light of the sky. If it were, east and west rows of trees should have a greater development to the south. Is this observed?

An interesting persistence of wind effect is seen in Figure 17. Apparently hillside creep has caused the trunk to lean downhill, as the earth yielded beneath it. As there was free exposure to light and wind the twigs have continued to grow over to eastward. There is no sign of a stump or branch lost from the east side.

I believe school teachers who are willing to go out-of-doors will find value in observations like these.

A SCHEME OF GEOGRAPHY *

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THERE is a certain profit in looking forward to the time when the Earth and its inhabitants shall have been so well studied that if all then known about them were put in print, the volumes thus formed would include the whole content of geography. The material there gathered might be arranged following either one of two

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