

CLIMATOLOGY OF COSTA RICA.

Communicated by H. FITZGER, Director, Physical Geographic Institute.

TABLE 1.—Hourly observations at the Observatory, San Jose de Costa Rica, during June, 1901.

Hours.	Pressure.		Temperature.		Relative humidity.		Rainfall.		
	Observed, 1901.	Normal, 1889-1900.	Observed, 1901.	Normal, 1889-1900.	Observed, 1901.	Normal, 1889-1900.	Observed, 1901.	Normal, 1889-1900.	Duration, 1901.
	660+	660+	° C.	° C.	%	%	Mm.	Mm.	Hrs.
1 a. m.	4.05	3.58	17.70	17.73	94	93	0.3	2.2	0.59
2 a. m.	3.73	3.23	17.59	17.49	93	93	0.3	1.7	0.06
3 a. m.	3.42	2.99	17.58	17.25	94	98	0.1	1.4	0.08
4 a. m.	3.33	2.95	17.37	17.09	94	98	1.1	1.2	0.91
5 a. m.	3.37	3.10	17.30	17.01	98	98	2.2	1.1	1.50
6 a. m.	3.61	3.41	17.16	16.91	92	92	0.8	0.9	2.50
7 a. m.	3.92	3.72	18.63	18.59	88	87	0.2	0.4	1.50
8 a. m.	4.10	3.95	21.13	20.53	74	81	0.0	0.5	0.00
9 a. m.	4.23	4.11	22.71	22.40	67	78	0.0	0.9	0.00
10 a. m.	4.26	4.11	24.33	23.90	64	69	0.0	1.9	0.00
11 a. m.	4.11	3.91	25.56	24.77	62	67	0.0	2.0	0.00
12 m.	3.73	3.62	25.28	25.10	65	68	0.0	4.3	0.00
1 p. m.	3.36	3.21	24.88	24.81	69	70	7.3	10.1	1.16
2 p. m.	3.02	2.83	23.67	23.77	75	74	24.6	27.0	4.08
3 p. m.	2.83	2.57	23.43	23.45	79	79	41.6	28.8	7.84
4 p. m.	2.70	2.54	21.84	21.84	84	84	38.6	33.1	6.33
5 p. m.	2.87	2.83	20.55	20.38	89	87	48.1	41.1	9.11
6 p. m.	3.24	3.15	19.56	19.72	92	89	37.1	48.6	9.46
7 p. m.	3.71	3.57	19.44	19.22	94	91	24.3	24.7	10.25
8 p. m.	4.10	3.90	19.17	18.87	95	92	16.2	18.8	7.46
9 p. m.	4.41	4.10	18.91	18.63	94	92	19.9	10.2	5.57
10 p. m.	4.54	4.24	18.69	18.35	95	93	13.5	4.0	6.28
11 p. m.	4.58	4.23	18.40	18.13	95	93	3.1	3.4	4.41
Midnight	4.36	3.98	18.20	17.83	95	92	2.5	2.3	3.58
Mean	663.73	663.47	20.35	20.12	85	85			
Minimum	660.60	660.73	14.6	13.20	38				
Maximum	665.70	666.12	29.5	29.50	100		22.1		
Total							238.6	290.6	82.19

REMARKS.—The barometer is 1,169 meters above sea level. Readings are corrected for gravity, temperature, and instrumental error. The dry and wet bulb thermometers are 1.5 meters above ground and corrected for instrumental errors. The hourly readings for pressure, wet and dry bulb thermometers, are obtained by means of Richard registering instruments, checked by direct observations every three hours from 7 a. m. to 10 p. m. The hourly rainfall is as given by Hottinger's self-register, checked once a day. The standard rain gage is 1.5 meters above ground. In the Costa Rican system the San Jose local time is used, which is 0° 36' 13 3" slower than seventy-fifth meridian time.

TABLE 2.

Time.	Sunshine.		Cloudiness observed, 1901.	Temperature of the soil at depth of—				
	Observed, 1901.	Normal, 1889-1900.		0.15 m.	0.30 m.	0.60 m.	1.20 m.	3.00 m.
	Hours.	Hours.	%	° C.	° C.	° C.	° C.	° C.
7 a. m.	7.03	9.79	75	23.05	22.32	22.86	22.05	21.36
8 a. m.	17.32	17.25						
9 a. m.	21.25	19.58						
10 a. m.	22.32	19.30	68	22.34	22.39	22.88	22.12	
11 a. m.	22.12	17.75						
12 m.	16.16	14.09						
1 p. m.	10.58	11.58	83	22.87	22.60	22.89	22.11	
2 p. m.	8.00	10.52						
3 p. m.	4.59	7.01						
4 p. m.	1.33	4.36	96	22.85	22.59	22.86	22.04	
5 p. m.	0.33	1.67						
6 p. m.	0.00	0.37						
7 p. m.			97	22.76	22.58	22.85	22.03	
8 p. m.								
9 p. m.								
10 p. m.			80	22.61	22.58	22.87	22.04	
11 p. m.								
Midnight								
Mean			84	22.59	22.51	22.88	22.07	21.36
Total	181.68	183.26						

Notes on the weather.—On the Pacific slope and at San Jose the general weather was about normal for the season. On the Atlantic side it was very dry on the coastal belt and rather wet in the upper region.

Notes on the earthquakes at San Jose.—During June none were felt.

TABLE 3.—Rainfall at stations in Costa Rica, June, 1901.

Stations.	Amount.		Stations.	Amount.	
	Mm.	No. rainy days.		Mm.	No. rainy days.
1. Sipurio	255	21	13. Turrialba	266	21
2. Boca Banano	51	13	14. Juan Vinas	276	23
3. Limon	33	7	15. Santiago	237	17
4. Swamp Mouth	24	6	16. Las Concavas		
5. Zent	50	20	17. Cartago		
6. Gute Hoffnung	98	12	18. Tres Rios	548	23
7. Siquirres	294	17	19. S. Francisco G	301	23
8. Guapiles	270	19	20. San Jose	234	23
9. San Carlos	433	23	21. La Verben.	341	24
10. Sarapiquí	432	28	22. Alajuela	240	14
11. Las Lomas	282	11	23. San Isidro Alajuela	333	23
12. Peralta	236	18	24. Nuestro Amo	309	23

REFORESTATION AND RAINFALL IN THE LEEWARD ISLANDS.

By W. H. ALEXANDER, Observer, Weather Bureau, dated May 28, 1901.

The forestry question has of late years assumed a place of unusual prominence in the Leeward Islands colony, owing to the alarming extent to which the destruction of native forests has been carried.¹ The chief industry, the production of sugar, being paralyzed and poverty being on the increase, the present population has been driven to other means of supplementing scanty wages, and one of these means is the burning of charcoal. Of course, to make the charcoal wood must be had and to get the wood trees must be felled. Hitherto this destruction of trees has been done in a most indiscriminate, not to say wanton, manner. So much so, in fact, that official notice began to be taken of the matter and we find the commissioner for the island of Tortola, in his report for 1899, referring to this matter in the following words, viz:

Charcoal burning constitutes a very important source of income to the people of this island, and is extensively carried on, with a deplorable effect on the soil and agriculture, and laying bare on the hills a naturally shallow soil to the action of rain and wind, and lessening the effect of the rainfall to a marked degree.

In August, 1899, the traveling superintendent of the imperial department of agriculture deals with this subject relative to the Virgin Islands in the following language, viz:

The destruction of forest trees, particularly those growing on the upper ridges, is a very serious matter and deserves careful attention. Indeed it is not too much to say that on the protection of the remaining forest lands the future agricultural development of the island largely depends. Each year witnesses the destruction of fresh areas of forest for the purpose of charcoal burning, and as the lower slopes become cleared, the charcoal burner finds it necessary to extend his work of destruction to the upper ridges. About the center of the island there is a large area of several hundred acres at an elevation of 1,000 feet, from which the forest has entirely disappeared. This district is now a bleak and wind-swept waste, from which the upper layers of soil have been removed by the action of the wind and rain. There is abundant evidence that Tortola once possessed numerous streams of running water. There are few now. * * * There can be little doubt that the continuation of such a system of forest destruction will in time have a very serious effect on the climatic conditions of the island.

These and other representations relative to the subject were laid before the Secretary of State for the Colonies, London, and on October 3, 1899, he addressed a letter to the governor of the Leeward Islands, urging upon him the the impor-

¹ See the following documents filed in the Library of the Weather Bureau as Nos. 22364, 22365, and 22366:

Correspondence relating to the preservation of forests and reforestation in the Leeward Islands. Printed by the Imperial Department of Agriculture for the West Indies. For official use only. By V. Gale, printer to the government of Barbados. 1900.

Report of a Select Committee of the Legislative Council on forest preservation in St. Kitts and Nevis (appointed May 17, 1900).

Circular letter from Charles T. Cox, administrator, dated Government House, St. Kitts, 9th of March, 1901, communicating an ordinance to establish a forestry board.

tance of taking immediate action looking to the preservation of existing forests and the reforestation of such areas as might be deemed advisable. The Secretary in his letter outlines the work in about this way, viz:

1. The determination of the altitude above which the forests should be preserved; suggesting also that this altitude must vary in the different islands.

2. The question of reservation: that is the right of entry on the part of the government to private lands to see that the law is being observed and to settle all questions of compensation, etc.

3. The machinery for enforcing the law when passed.

Acting upon this letter, the governor opened up correspondence with Dr. Morris, Imperial Commissioner of Agriculture for the West Indies, and with the various administrators, asking for suggestions as to the best means of accomplishing the desired ends. I do not know the final results of this correspondence as indicated in the local measures adopted in the various islands, but I am credibly informed that action in the matter is at about as advanced a stage in this presidency (St. Kitts-Nevis) as in any island of the colony. The authorities here took the matter in hand with commendable zeal and were among the first to arrive at something definite. Among the first and most enthusiastic advocates of the subject was Mr. L. M. Kortright, Superintendent of Public Works, who early in 1900 prepared and submitted to the administrator for consideration a draft ordinance. In his letter of transmittal, Mr. Kortright makes this statement of the work in hand, viz:

The highest observed point at which canes are planted is 1,000 feet above sea level. I believe this to be the extreme limit at which canes can be grown at a profit. In fact, I have been informed on good authority that above 800 feet canes cease to be profitable, for agricultural and climatic reasons.

GENERAL SCHEME.

(1) The present elevation on each estate of cane plantation to be considered as the limit at which canes can be grown at a profit.

(2) A belt of forest trees above the canes for about 100 feet vertical.

(3) Above this line, a belt, of say, 200 feet vertical, to be reserved for pasture and ground provisions.

(4) Above this line the forest to be replanted when necessary and preserved.

(5) All steep hill sides in the lower levels to be planted in forest and preserved. This refers to such places as Monkey Hill, Brimstone Hill, Ottley's Level, Blakes Mountain, etc.

(6) All ravine sides to be re clothed and preserved.

(7) All lands to be under the charge of a forestry board for the above purposes.

(8) Estates to be liable for carrying out the work and to be paid so much an acre for a term of years.

(9) Land tax to be remitted on forest lands.

(10) An export duty of so much per ton to be levied to pay estates for carrying out the work and to create a fund for the future maintenance of forests.

With a view to the application of these general principles to the individual requirements of each estate I have ventured to frame a draft ordinance, which I forward herewith. I must disclaim any legal knowledge and have merely adopted this plan as being the readiest way of explaining my views.

It is not necessary for the purposes of this paper to give the ordinance in full. It sets out by making provision for a forestry board, and then defines the powers of said board, as follows, viz:

4. Subject to the provisions of this ordinance the forestry board shall have and exercise full and exclusive control over the estate, or plantation, or property declared by the legislative council to be subject to the provisions of this ordinance for the following purposes:

(a) For the establishment of a belt of forest extending from the highest points of the existing cane cultivation to such elevation and following such a contour as the configuration of the land or other local causes renders necessary or desirable.

(b) The establishment of a belt of pasture or provision land above the last-mentioned elevation, and extending upward to such elevation and following such a contour as the configuration of the land causes or renders possible or desirable.

(c) The establishment of forest above the last-mentioned elevation as high as the estate, plantation, or property extends.

(d) The establishment of forest on the banks and sides of all ravines.

(e) The establishment of forest on the sides or slopes of all hills and steep declivities within the limits of the estate, plantation, or property.

(f) In respect of all the above-mentioned subsections the full and exclusive power to plant or cause or permit to be planted such trees or other vegetation as may appear from time to time best suited for the particular locality and to replant or cause or permit to be replanted such trees or other vegetation; and to lop and prune the same or cause or permit to be lopped and pruned; and to drain, embank, and support the land, or cause or permit the said land to be drained, embanked, and supported; and to give control and direct the character of the cultivation; and to do or cause to be done such other things as may be necessary to give effect to the meaning and intention of this ordinance.

(g) The issuing and cancellation of licenses to cut timber and to burn charcoal.

Provided always, that nothing in the foregoing shall be construed as infringing any of the rights or privileges of owners of estates, plantations, or properties in fee simple; or restricting such owners in the free use of such timbers as may be required for their proper and legitimate use, or of the fruit or produce of such timbers, so long as such timbers, fruit, or produce are cut and removed under direction of the board.

Then follow articles of procedure and other details of execution of which it is unnecessary to speak in this connection. Suffice it to say, that this draft was duly submitted by the administrator to the legislative council of St. Kitts-Nevis, and a select committee was appointed to consider the matter and report thereon. From the report of this committee I make the following extracts, viz:

2. In addition to independent inquiries from persons whose long residence and means of observation lend weight to their opinions we have had before us a report and draft bill prepared by the superintendent of public works, together with a report thereon by the imperial commissioner of agriculture for the West Indies.

3. As our investigations have led us to indorse the views expressed in these documents in most respects we have deemed it convenient to accept them as a basis for our report, making such additions and alterations as suggested themselves in the course of inquiry.

4. The subject presents three aspects for consideration, viz:

(a) Influence of forest on rainfall.

(b) Influence of forest as affecting atmospheric humidity.

(c) Influence of forest in modifying floods and minimizing their destructive action on the arable lands.

We have been able to obtain records of rainfall, extending back for forty-four years, in Basseterre, and also for a less period of time in other districts. An examination of the plotted curves does not lead to the belief that the average rainfall has diminished within recent years. Nor, indeed, does the physical character of St. Kitts lend itself to such a supposition. The island consists of a central ridge of high mountains facing the northeast, the direction of the prevailing winds. The saturated winds from the Atlantic, meeting the mountain ridge, are forced upward until they are condensed in the colder altitudes and fall as rain down the mountain slopes.

6. With regard to the action of forest in affording humidity in its vicinity this is undoubtedly true, and in some localities the destruction of the forest vegetation has had a marked effect. As an illustration the case of Frigate Bay estate may be cited. This is a stock estate, lying at a low level, bounded on one side by the sea and on the other by a low ridge of hills, which were formerly in thick forest. In former years the humidity of the air afforded sufficient moisture to maintain the pasturage in good condition. Now, however, every stick of timber has been felled for burning into charcoal, with the result that the climatic conditions of the estate have been entirely altered. The remedy for this lies in re clothing in forest all the ravines which, like the ribs of a fan, radiate from the central ridge to the sea; and, as regards the low-lying districts, replanting in forest the various ridges, prominences, and steep declivities which are at present in low scrub or ground provisions.

7. With regard to the disastrous effect of the denudation of the mountain slopes in causing destructive floods we need hardly occupy the time of the council to any great extent by dwelling on the causes which have led to the deforesting of the high mountain lands. Briefly stated they are due to the clearings by small renters for growing ground provisions. As the forest recedes his patch of land becomes unproductive from increased aridity and from exposure to storm waters. He then clears another patch of forest at a higher level with a like result in the course of time. And so the process continues. Another cause is the wanton and indiscriminate destruction of mountain timber for charcoal burning. An instance of this destruction is quoted by Doctor Morris on the authority of Mr. Joseph Briggs of Nevis, in paragraph 10 of his report of the 20th of April, 1900. The result of this wholesale destruction of forest vegetation is the increased violence of storm waters, which everywhere rush through valuable cane lands, carrying destruction and loss not only to the estates themselves, but to the different towns and villages situated at lower levels.

8. To sum up the result of our inquiry we are of opinion—

1st. That immediate steps should be taken to protect all remaining forest areas.

2d. That charcoal burning should only be permitted under proper control and subject to regulation.

3d. That a considerable portion of the lands at high elevations and now in ground provisions or abandoned, together with all ravine sides, ridges, and prominences in the lower levels, should gradually be re-clothed as funds become available.

Perhaps the most important change recommended by the committee in the scheme as presented by Mr. Kortright is that the belt of pasture land lie immediately above the cane lands instead of being separated therefrom by a belt of forest. This change being made together with a few other immaterial alterations, the draft as presented by its author will go to the council for its approval in a short time. If I am correctly informed in the matter it will be passed by the council without delay, and the work of execution begun at once.

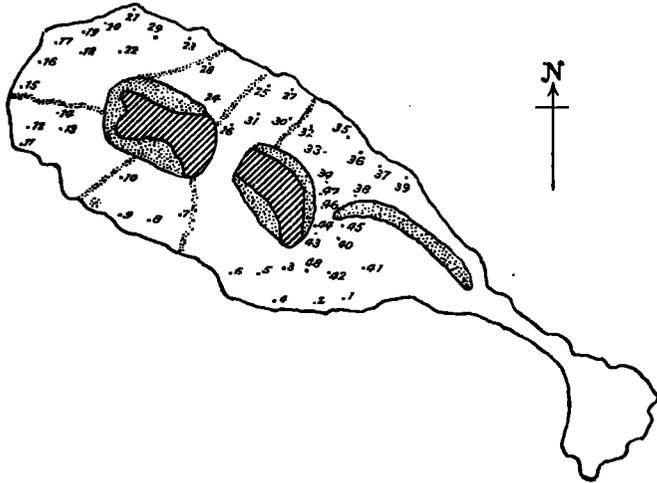


FIG. 1—St. Kitts, W. I.

Existing forest area, section lined. Probable area of reforestation, dotted. There are many minor areas which would probably be placed in forest, not shown.

Reference table.

Number on map.	Name of rainfall station.	Height above sea.	Number on map.	Name of rainfall station.	Height above sea.
1	Buckley	140	25	Mills	100
2	Camp	80	26	Phillips	550
3	Ben Lomond	600	27	Bouryeaux	100
4	West Farm	120	28	Estridge	350*
5	Ottley P. P. ....	.....	29	Lavington .....	.....
6	Stone Fort	270	30	Lodge	300
7	Wingfield	200	31	Molyneux	360
8	Lamberts	170	32	Brighton	375
9	Con Phipps	100	33	Spooner	290
10	Vambelle	500	34	Whites	650
11	Leper Asylum	50	35	Hermitage .....	.....
12	Bourkes	130	36	Cunningham .....	.....
13	Burts	400	37	Canada Lower	130
14	Farm	290	38	Canada Upper	520*
15	La Vallee	100	39	Conaree .....	.....
16	Cranstouns	300*	40	Needsmust	50
17	Brothersons	90*	41	Pond	10*
18	Belmont .....	.....	42	Shadwell	150*
19	Willetts	50*	43	Millken	800
20	White Gate	70*	44	Fountain	850*
21	Caines	25	45	Stapleton .....	.....
22	Profit	400	46	Bayfords .....	.....
23	Bellevue .....	.....	47	Green Hill .....	.....
24	Mansion	320	48	Olivees	460

* Estimated.

So much, then, for the formative stage of the question. In order to arrive at something of an idea as to just what is hoped to be accomplished I have asked Mr. Kortright to prepare for me a map of St. Kitts showing the location of existing forests and the lands that it is proposed to reforest. The accompanying map, fig. 1, is the answer to my request. This map should be studied in connection with the one on page 487, MONTHLY WEATHER REVIEW for November, 1900, and it will then be observed that the forest areas as they now exist are simply the mountain tops and that it is proposed to reforest the mountain slopes and the banks of the streams. The figures on the map and the reference table are valuable

only as locating stations from which rainfall data have been collected, and may be helpful in studying the climatology of St. Kitts. The elevations marked "estimated" were put in by me and were obtained from the persons rendering the rainfall reports. All other entries are by Mr. Kortright.

There are many and substantial reasons for the planting of trees, so many in fact, that it is quite unnecessary to drag in fallacious arguments because expectations based upon conclusions drawn from false premises are almost certain to bring disappointment, resulting in a hasty and unreserved condemnation, in toto, of a really meritorious measure. The results that may be reasonably expected must be known before it can be determined whether or not the expense is justified. Of course in this particular case the matter has passed beyond the argumentative stage but no harm can possibly come from the statement of a few facts—the teachings of meteorology are abundantly substantiated by experimentation.

It is quite evident from the correspondence relative to the subject of reforestation that in many minds there still lingers a vague idea that the rainfall is actually increased or decreased by the existence or nonexistence of forests. This idea finds neither encouragement nor support in the extensive experiments made, notably in India, on this very point. Professor Abbe, writing on this line, says:

As regards the effect of forests and deforestation on rainfall, you may safely assert that it is absolutely inappreciable; but the effect of the protection from wind on the catch at the gage is very considerable. Thus, in India, in a certain barren region, the gages caught little rain. As the forest grew up the gages caught more rain, while the gages just outside the forest region caught just the same as ever, and gages raised on high supports above the trees caught as little as before, showing that there had been no change in the rainfall, but merely a change in the error introduced by the action of the wind on the falling drops at the mouth of the gage.

Of course, all the waste land in the island not used for sugar or food crops should be devoted to the best forest growth, not only for the crop but for the protection against storm winds and for aesthetic purposes. The accumulation of rich soil beneath forests and the retention of water in shaded forest soil is so important that forest growth should be encouraged by rewards and barren wastes be discouraged by taxation.

The conclusion of the whole matter, then, seems to be that trees are valuable as conservators of moisture, as a protection against winds and floods, as timber, and for aesthetical purposes; but there is absolutely no good reason for hoping to increase the rainfall by planting trees.

MEXICAN CLIMATOLOGICAL DATA.

Through the kind cooperation of Señor Manuel E. Pastrana, Director of the Central Meteorologic-Magnetic Observatory, the monthly summaries of Mexican data are now communicated in manuscript, in advance of their publication in the Boletin Mensual. An abstract, translated into English measures, is here given, in continuation of the similar tables published in the MONTHLY WEATHER REVIEW since 1896. The barometric means are now reduced to standard gravity.

Mexican data for June, 1901.

Stations.	Altitude.	Mean barometer.*	Temperature.			Relative humidity.	Precipitation.	Prevailing direction.	
			Max.	Min.	Mean.			Wind.	Cloud.
Culiacan (Sin.)	Feet. 112	Inch. 29.60	° F. 103.5	° F. 69.1	° F. 85.5	% 55	Inch.	s.	ne.
Durango (Seminario)	6,243	23.98	98.6	48.2	75.0	25	0.05	ne.	e.
Leon (Guanaajuato)	5,906	24.21	93.0	55.6	75.6	34	1.26	ese.	sw.
Linares (Nuevo Leon)	1,188	28.55	98.8	64.4	83.5	59	8.62	s.	se.
Mazatlan	25	29.80	86.2	69.3	79.2	77	T.	n.	.....
Mexico (Obs. Cent.)	7,472	22.98	86.2	51.8	66.0	54	1.52	n.	.....
Morelia (Seminario)	6,401	23.88	87.8	53.8	69.8	59	2.31	sw.	e.
Puebla (Col. Cat.)	7,125	23.31	84.7	53.6	69.6	54	4.59	e.	sw.
Saltillo (Col. S. Juan)	5,399	24.71	91.4	57.2	74.5	63	0.67	nw.	s.
S. Isidro (Hac. de Gto) .....	.....	.....	86.0	71.6	.....	.....	1.38	.....	.....
San Luis Potosi	6,202	24.05	89.2	59.0	73.4	50	0.11	e.	e.
Toluca	8,812	21.91	84.0	39.2	61.7	54	3.34	w.	e.
Zapotlan (Seminario)	1,548	25.00	95.0	55.2	73.9	52	1.91	ese.	w.

* Reduced to standard temperature and gravity.