BULLETIN No. 178 JULY, 1914

ALABAMA

Agricultural Experiment Station

OF THE

Alabama Polytechnic Institute

AUBURN

Boll Weevil Effect Upon Cotton Production

By
W. E. HINDS
Entomologist

Opelika, Ala.
Post Publishing Company
1914

COMMITTEE OF TRUSTEES ON EXPERIMENT STATION.

HON. R. F. KOLB ..... Montgomery
HON. H. L. MARTIN ..... Ozark
HON. A. W. BELL ..... Anniston

STATION STAFF

C. C. THACH, President of the College.
J. F. DUGGAR, Director of Experiment Station.

DEPARTMENTAL ORGANIZATION

AGRICULTURE:

J. F. Duggar, Agriculturist.
E. F. Cauthen, Associate.
M. J. Funchess, Assistant.
J. T. Williamson, Field Agent.
O. H. Sellers, Assistant.
H. B. Tisdale, Assistant.

VETERINARY SCIENCE:

C. A. Cary, Veterinarian.
I. S. McAdory, Assistant.

CHEMISTRY:

B. B. Ross, Chemist, State Chemist.
J. T. Anderson, Chemist, Soils and Crops.
C. L. Hare, Physiological Chemist.
T. Bragg, First Assistant.
S. Adler, Assistant.

EXTENSION:

L. N. Duncan, Superintendent*
J. B. Hobdy, Assistant.*
N. A. Negley, Assistant.*
Mrs. Birdie I. Robinson, Assistant.*
C. S. Jones, Assistant.*

BOTANY:

J. S. Caldwell, Botanist.
A. B. Massey, Assistant.

PLANT PATHOLOGY:

F. A. Wolf, Pathologist.

HORTICULTURE:

Ernest Walker, Horticulturist.
J. C. C. Price, Associate.
G. V. Stelzenmuller, Field Agent

ENTOMOLOGY:

W. E. Hinds, Entomologist.
J. E. Buck, Assistant.
G. W. Ells, Field Agent.

ANIMAL INDUSTRY:

G. S. Templeton, Animal Husbandman.
E. S. Girton, Assistant.
S. S. Jerdan, Assistant.*
A. R. Gissendanner, Assistant.
J. A. McLeod, Assistant.

*In co-operation with United States Department of Agriculture

BOLL WEEVIL EFFECT UPON COTTON PRODUCTION.

W. E. HINDS, *Entomologist.*

Numerous studies have been made of actual cotton yields produced in various sections before and after the advent of the Mexican cotton boll weevil but few, if any, of these studies have attempted to deal with the entire cotton belt or to establish a sound basis of comparison by which it might be possible to anticipate in any particular region the extent of injury that might be expected there when the weevil should become thoroughly established.

CLIMATIC AND LIFE ZONES.

Everyone is familiar with the great general regions or climatic zones which we call the frigid, temperate and torrid zones. We recognize also that the combination of climatic conditions found in each of these zones has a marked influence upon the forms of plant and animal life occurring therein. We know that the development of both plant and animal life is most rapid and abundant in the torrid zone and decreases gradually from that zone to the polar conditions where no forms of either plant or animal life are known.

Within each of these great regions, a close study reveals smaller subdivisions extending in a general way east and west as transcontinental life zones. The factors primarily responsible for the definition of these life zones may be briefly stated as follows: 1. The total heat above about 43 deg. F. occurring or accumulating during the summer season. 2. The occurrence of extreme conditions of either maximum heat and dryness during a period of perhaps six weeks in summer or the occurrence of extreme cold that would result in the destruction of the species in winter.

Studying particularly the boll weevil and its single host—cotton-plant—we find a case where the insect species has been for so long associated with the host-plant that it seems to be unable to exist upon any other plant. It is certain, therefore, that the two species have developed originally within the same territory under such climatic conditions that the cotton was native and probably naturally perennial. As the range of cotton has been extended commercially, the range of many of its original insect pests has also extended accordingly. In the case of the boll weevil, we have a recently introduced species (entered

Texas from Mexico in 1892) which, in 21 years time, has spread steadily year by year at an average rate of about 50 miles, as is shown clearly upon the map in Fig. 1, pages 92-93. As cotton has shown its adaptability to a somewhat more northern climate than that in which it originated, so the boll weevil has also shown a marked power of adaptation to a similar change in climatic conditions. Its steady progress leads us to believe that it will ultimately occur practically throughout the cotton belt, but it is certain that the degree of its damage will not be uniform through this extensive area. Life history studies of the weevil have shown that there is about one less generation of weevils in the latitude of North Texas or at 33 degrees north latitude, than occurs in South Texas at 29 degrees. In a general way accordingly boll weevil injury decreases as we pass from those conditions which are most like the torrid to the cooler and drier portions of the cotton belt.

From an extensive study of weather bureau reports covering the entire cotton belt for as long a period as the records have been kept, it is evident that we may reasonably outline certain zones in which occur practically uniform conditions, both as to temperature and rainfall during the fruiting period of the cotton plant. Before taking up the basis for this study, however, it will be well to consider the effect of some of the more unusual conditions upon weevil occurrence and injury.

Some Factors in Natural Control of The Boll Weevil.

Climatic Conditions: By far the most important factors in natural control are climatic conditions which may limit the distribution of either the food plant or of the insect pest. Extremes of heat and drought are most important when they occur at the beginning of the fruiting season and continue for six weeks or more. As an illustration of the effect of this extreme condition, we may note that the weevil was exterminated in West Texas and South Central Oklahoma in May and June, 1911, during which period there occurred in that area a rainfall totalling less than 1½ inches in eight to ten weeks. During that period maximum temperatures commonly exceeded 100 degrees F., and in some localities reached as high as 116 degrees F., in the shade. This was too much for the boll weevil and almost more than human beings or cotton plants could endure. The reduction of weevil infested area is shown

on the map by the broken line of 1911. The weevil is now steadily spreading back into the area then lost, but has not fully recovered it.

Extremes of cold and wet in winter have also occasionally exterminated the weevils and temporarily checked their advance. This happened in Central Arkansas and Northern Mississippi in the winter of 1911 to 1912 when mimimum temperatures through that newly infested area went much below the normal point.

So far as Alabama is concerned, a study of the weather bureau records shows that we have no reason to anticipate any such period of extreme heat and drought as that referred to in Western Texas and that only in the Tennessee Valley or northward or in the mountainous regions of Northeast Alabama may control by extreme low winter temperatures often occur.

Early Frosts: Extremely early frosts have a decided influence in checking the fall multiplication of the weevils and in reducing the number to enter winter quarters. This occassional control of the weevil by early frosts demonstrates the possibility of controlling it by such general early destruction of stalks as has long been recommended but little practiced in infested territory. Such early frosts occurred in Alabama about Oct. 29, 1910, throughout the northern half of the State and about Oct. 20, 1913, when cotton was killed generally throughout the State.

Cotton Worm Effects: The occasional general stripping of cotton by the cotton worm in late summer or early fall has much the same influence as does the occurrence of early frosts or the early destruction of stalks as it removes the possibility, or reduces the probability, of abundant late breeding by the weevils. Cotton worm occurrence was general throughout the cotton belt westward from the eastern border of Alabama in 1911 and cotton was stripped on smaller areas, mainly in Louisiana and Texas, in 1912.

Combination of Factors Greatly Reducing Weevils, 1911-1912: A very remarkable series of unusual controlling factors should be carefully noted. Beginning with the frost of October, 1910, we may note following it the extreme hot, dry period occurring in the early summer of 1911, followed by general cotton worm occurrence in the fall of the same year and by an unusually severe winter in 1911-1912. This series of checks undoubtedly reduced the weevils to very much smaller numbers throughout the infested area than had ever

before been known. Partly as a consequence of this the cotton crops of 1911, 1912, and 1913 were markedly superior to any preceding. In the weevil area in many sections, very little weevil damage occurred, especially in 1912 and this reduction in weevil numbers during recent years has given rise to a very wide-spread impression that the weevil has been permanently reduced both in numbers and in its power to injure cotton. Consequently, sections which had previously largely reduced their acreage in cotton were encouraged to increase that acreage again and counties which had fallen very low in their cotton yield have been showing a large degree of recovery in cotton production.

Whether this condition of reduced weevil injury will be long maintained, we frankly doubt, but surely this renewal of confidence in their ability to make cotton in spite of the weevil should have a permanently helpful effect.

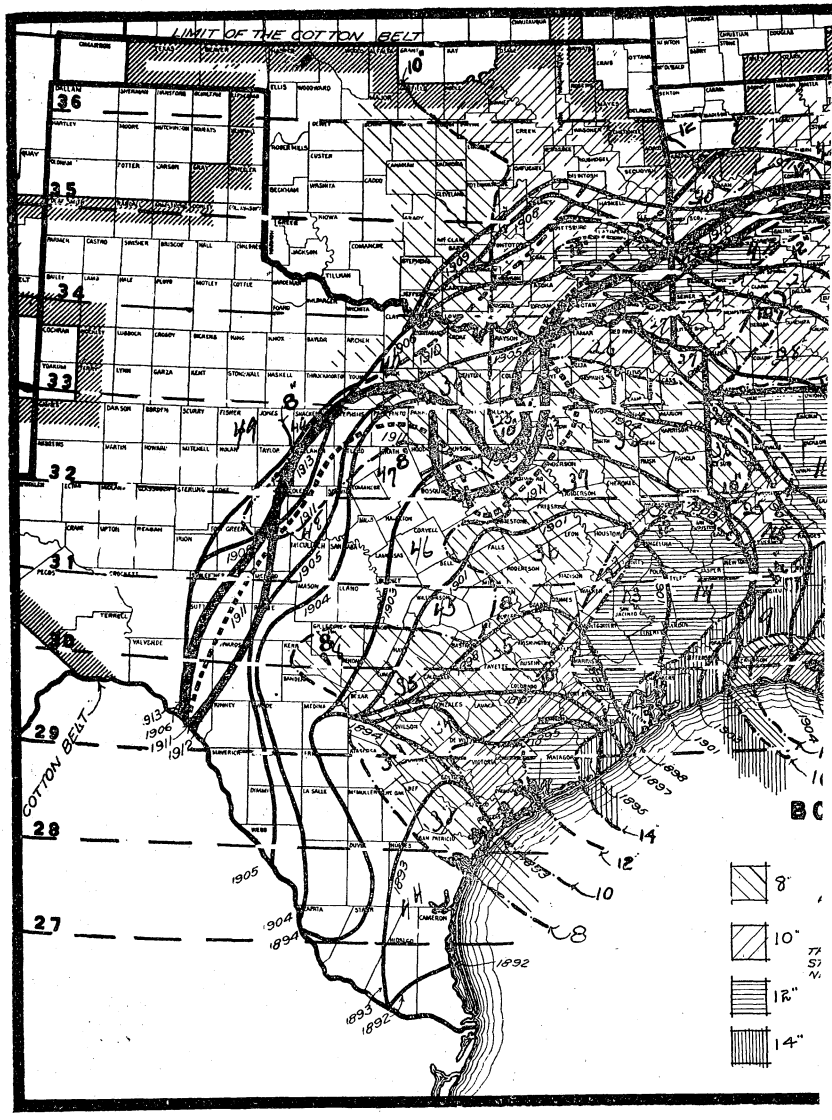
Basis of Study of Weevil Effects According to Rainfall Zones.

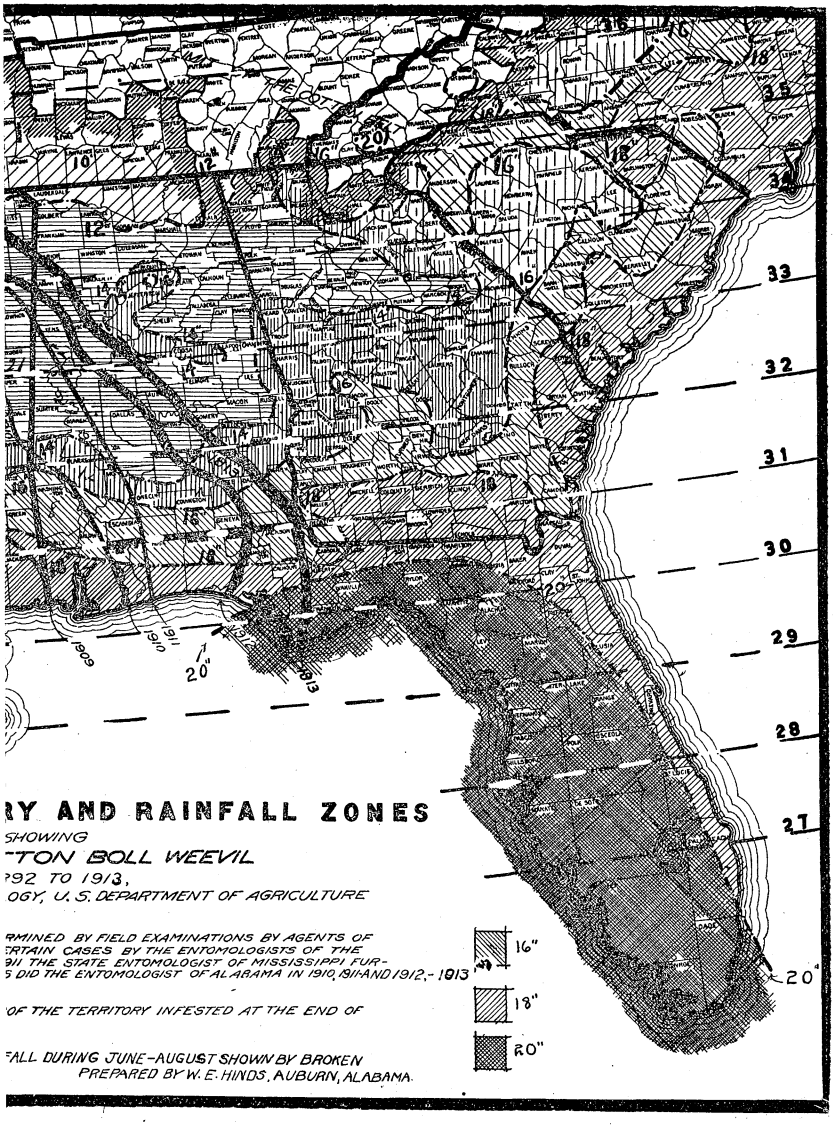
Taking as a base, the map prepared by the U. S. Bureau of Entomology, showing the cotton belt and the area of weevil occurrence for 1913, we have added thereto the lines of latitude crossing the main portion of the cotton belt. The most important portion of the rainfall in its effects both upon the cotton plant and the boll weevil is that falling during the principal fruiting season of cotton, that is, as a general thing, from June 1st to August 31st each year. These three months have been selected therefore, as the period to be considered in determining rainfall zones. Taking all of the Weather Bureau records showing the average or normal rainfall for each reporting station during the entire period for which records have been kept, we have charted on the map the general lines for variations of 2 inches in normal rainfall during this three-month period. It will be noted that the heaviest rainfall occurs in Florida and close to the Gulf and Atlantic coasts. The zones are quite irregular in outline and have a general tendency to follow the coast outline more closely than they do lines of latitude. The most striking reduction in rainfall occurs in Southwest Texas and Oklahoma where cotton is raised under the most thorough cultural conditions.

The basis for the study of cotton yields is found in the cotton production reports issued by the U. S. Bu-

reau of the Census. The groups of counties studied together are those lying in a general way adjacent and included within the 2-inch rainfall zone lines and the weevil advance lines as shown year by year. These areas must be considered as having very similar conditions both as to rainfall and extent of weevil infestation each year. In determining what may be considered as the normal cotton yield for each group of counties, we have in nearly all cases where the figures are available, taken an average for the last five years before weevil infestation began to affect the crop. To show the present tendency of cotton production, we have taken the average yield for the last five years, 1909 to 1913, or such portion thereof as may come within the period of actual weevil infestation. In some such cases the injury has not yet reached its maximum. We have studied also the maximum and minimum yields for each group of counties and the 1913 yields. Taking the first five-year period before infestation as the base, or normal yield, we have determined the percentage for each group of figures as shown in Table 3. We feel that this method of study is the most thorough, comprehensive and reliable that has yet been attempted on this subject. By this method it is possible to establish a basis determining approximately what degree of damage may be anticipated in other sections as the boll weevil continues its advance.

It may not be generally known that the cotton acreage for the United States amounted to 24,275,000 acres in 1899 and increased to over 32,000,000 acres in 1909. In this 10-year period there was a general increase of 32 per cent in acreage in the cotton belt, while in Texas alone there was an increase of nearly 3,000,000 acres or 42 per cent of the acreage of that state. Naturally it is impossible adequately to consider weevil effects upon state yields where the increase in acreage is so great and only a portion of the area infested. One of the powerful factors in increasing the acreage in cotton has been the advance in price of cotton which occurred notably between 1902 when it sold at 5c and 6c per pound and since 1910 when the price has ranged from 10c to 14c or more. The boll weevil may fairly be credited with a large portion of this increase in the price of cotton.


LIMIT OF THE COTTON BELT
COTTON BELT
36
35
34
33
32
31
30
29
28
27
8"
10"
12"
14"


RY AND RAINFALL ZONES
SHOWING
TTON BOLL WEEVIL
92 TO 1913.
OGY, U. S. DEPARTMENT OF AGRICULTURE
RMINED BY FIELD EXAMINATIONS BY AGENTS OF
RTAIN CASES BY THE ENTOMOLOGISTS OF THE
911 THE STATE ENTOMOLOGIST OF MISSISSIPPI FUR-
S DID THE ENTOMOLOGIST OF ALABAMA IN 1910, 1911 AND 1912,-1913
OF THE TERRITORY INFESTED AT THE END OF
FALL DURING JUNE-AUGUST SHOWN BY BROKEN
PREPARED BY W. E. HINDS, AUBURN, ALABAMA.
16"
18"
20"
1909
1910
1911
1912
1913
20"
33
32
31
30
29
28
27

Weevil Effect Upon Yield of Cotton Per Acre.

Boll weevil effects upon cotton production are shown most accurately by the actual yield of lint cotton per acre. The acreage figures for cotton are, however, determined for each county only once in ten years in connection with the census and it is, therefore, impossible to make as full and minute a study of the variations in yield per acre as we would like to do. The Department of Agriculture does estimate the acreage by states each year and these figures together with those of cotton production as issued by the Bureau of the Census form the basis for the figures given in tables 1 and 2 below. The period covered by this study extends for twenty years from 1893 to 1912. In the beginning of this period the weevil had just entered Texas but did not affect the yield of that state appreciably before 1896. It must be borne in mind that as yet Louisiana is the only state that is wholly infested. At the end of 1912 practically only one-half of Texas, Mississippi and Arkansas could be considered as infested. At that time the weevil had done very little damage to the total yield of Alabama and this state may, therefore, be considered in the group of uninfested states. The general upward or downward tendency of cotton yields is shown in tables 1 and 2 by 5 and 10 year comparisons. In this way, variations in seasonal conditions are averaged and comparisons are, therefore, put upon a more accurate basis.

Table 1.

Infested States. Average Cotton Yields Per Acre by 5-year Periods.

Period.	Texas.	La.	Miss.	Ark.
	lbs.	lbs.	lbs.	lbs.
1893-97	196	259	216	167
1898-1902	191.6	266.2	202.8	220.8
[a]1903-07	169	228	212.8	192.6
1908-12	174.8	156.2	185	187.2

a This line indicates approximately the time that weevil effects became noticeable upon state yields.

Average Yield Before and After Infestation.

	lbs.	lbs.	lbs.	lbs.
Before	193.8	251	210.5	226.8
After	171.9	156.2	185	187.2
Decrease after infestation	11.3	38	12	17.5

Three states, each one-half infested, decrease averaged 13.6 per cent.

One state wholly infested decrease averaged 38 per cent.

If Texas, Mississippi and Arkansas were wholly infested,

they would show a net decrease of approximately 27 per cent. This decrease, taken with net increase, in uninfested states of 10.8 per cent indicates that actual direct boll weevil injury in the infested area has amounted to 37.8 per cent. Compare this statement with conditions in Louisiana, where the decrease is about 38 per cent. Evidently most of the decrease in state or county yields beyond 35 to 40 per cent may be chargeable to reduced acreage in cotton, as a general rule.

TABLE 2.

Uninfested States. Average Cotton Yield Per Acre by 5-year Periods.

Period	Ala. lbs.	Ga. lbs.	S.C. lbs.	N.C. lbs.
1893-97	167	176	210	199
1898-1902	164.2	180.8	183.4	194.4
1903-07	170	183.6	200.6	217.8
1908-12	173.6	192.8	231.2	212.6
AVERAGE YIELD BY 10-YEAR PERIODS.				
1893-1902	165.6	178.8	191.7	196.7
1903-12	171.8	187.2	215.9	215.2
Increase Second Period.	10.4	10.5	11.3	10.9

Four infested states average increase 10.8 per cent.

It is interesting to note the rank of the various states in the amount of yield per acre as shown in tables 1 and 2. Before weevil occurrence, Louisiana easily held first place through fifteen years. As soon as infestation became general throughout that State she immediately dropped to eighth place while South Carolina assumed the lead. Alabama has usually stood at the bottom of the list in acreage yield and has gotton out of the last place only during the 1903-07 period when Texas was suffering most severely from the weevil and in the last five years only when Louisiana has dropped so low because of weevil work. These figures are not complicated by any question of reduction of acreage such as is unavoidable in connection with the following study of yields in county units through the various states.

WEEVIL INJURY ACCORDING TO RAINFALL ZONES.

Each rainfall zone as referred to should be definitely located by a study of the map on pages 92-93. The results of extended tabular studies are stated briefly for each zone in table 3.

TABLE 3. WEEVIL INJURY ACCORDING TO RAINFALL ZONES.

Rainfall June-Aug Inches	Area Included: No. Cos.	State	First (a) Infestation	Average Yields—Bales: A. Before W.	B. Last 5 yrs.	C. Max. crop	D. Min. crop	E. 1913	Percentage, Taking A as Base: B. Yield last 5 yrs	C. Max. yield	D. Min. yield	E. 1913 yield
20-18	4	La.	1908-1910	(b) Cotton crop is small. Has lost 70% from normal, and is probably not yet down to minimum. 1908 infested area lost 85 per cent.								
	4	Miss.	1910									
	2	Ala.	1911	63,560	19,480	82,599	13,531	19,412	**30**	130	21	**30**
18-16	8	La.	1907-1908	(b) Infestation averages older than that above. Average loss 83%; no recovery here evident as yet.								
	6	Miss.	1909-1910									
	1	Ala.	1911	231,600	38,650	289,383	24,191	35,602	**17**	125	10.4	**15**
16-14	6	La.	1906-1910	(b) Infestation nearly at maximum; loss 59% on last 5 years; 1913 crop only 29% of normal; tendency still downward.								
	10	Miss.	1909-1911									
	3	Ala.	1911	366,700	150,350	404,286	84,394	104,600	**41**	127	23.	**29**
14-12	11	Texas	1895-1904	(b) This is the heart of the cotton belt; loss 34% on last five years; 1913 crop 70% of normal; only some Texas counties exceed normal; two-thirds of Alabama lies in this zone.								
	21	La.	1905-1909									
	28	Miss.	1909-1912									
	3	Ala.	1912	1,034,300	680,116	1,290,652	487,496	711,207	**66**	125	47	**70**
12-10	12	Texas	1902-1907	(b) All this territory lies west of Mississippi river; period of greatest loss was 1907-09; under favorable conditions of past few years yield has even exceeded normal. Natural control important here.								
	3	La.	1905-1906									
	26	Ark.	1907-1912									
	9	Okla.	1907-1909	1,431,200	1,491,250	1,923,400	929,151	1,636,983	**104**	134	65	**114**
10- 8	73	Texas	1894-1906	(b) This is principally in open prairie country; much of it lies along the edge of infestation; general increase in cotton production is shown; weevil will never be very serious here. No Alabama territory comparable.								
	2	La.	1905									
	11	Ark.	1907-1910									
	5	Okla.	1907-1908	1,955,600	2,310,800	2,973,344	1,279,714	2,462,794	**118**	152	65	**126**
8 and less	35	Texas	1893 to Uninfested	(b) This is also open country, much of it at altitude of over 1000-1500 ft.; so dry that weevil cannot do much harm, and cotton crop is often cut by drought. E.g.—In nine uninfested counties, lying outside weevil area, yield for past five years has been only 80% of that from 1902 to 1906.								
				588,800	627,000	950,420	396,639	573,602	**107**	161	67	**97**

(a) First infestation is considered as being for the crop following the first occurrence of the weevils.
(b) Comments summarizing general conditions.

The 20-inch to 18-inch rainfall zone touches only Mobile and Baldwin counties in Alabama. In neither of these counties has cotton ever been a crop of great importance. After only two years of infestation, the crop in those two counties has dropped to one-third of its normal during the preceding five years and the prospect is that the decrease will be still greater. Taking the 20-inch to 18-inch zone as a whole, we notice that the infestation is comparatively recent and the average yield for the past five years represents, therefore, largely a condition of incomplete infestation. It is possible that the yield will still further decrease as has already happened in the 18-inch to 16-inch zone where the infestation has occurred for a longer period. In the latter zone it is evident that cotton production has been found extremely precarious and the yield for 1913 was but 15 per cent of the normal. The minimum yield throughout a large area, 15 counties, is shown in this zone with 10.1 per cent. These minimum crops occurred in 1910, 1911 and 1913, in each case being the third or fourth year after the infestation really began. At least eight South Alabama counties lie in this zone. No Texas counties have over 16 inches rainfall.

In the 16-inch to 14-inch zone we reach the extreme eastern coast counties of Texas. In these, cotton production is a very small item and they have been left out of the count in the tables. In the 19 counties considered, the loss has averaged about 60 per cent, the recent crop being still lower. Cotton production in this territory will require a hard fight to make it successful. About 10 Alabama counties lie in this zone. Throughout this territory it would seem that there must be extensive diversification, live stock raising, etc.

Within the 14-inch to 12-inch zone we consider 63 counties ranging from East Texas through Northern Louisiana and including Northeast Mississippi and the major portion of Alabama. In this zone are found the average conditions of the cotton belt with no extremes of rainfall, drought or winter cold. In this territory the weevil is bound to continue its existence, doing considerable damage every year and with a good fighting chance for the farmer who will reduce his acreage and make his own corn and meat. The yield has averaged, in the past five years, 66 per cent of the normal crop, while the 1913 yield is slightly better on account of the inclusion of three Alabama counties which had only one year of infestation and, therefore, succeeded in producing an increased yield over the normal.

Within the limits of the 18-inch to 12-inch zones of rainfall lies practically all of Alabama's cotton territory. Within these zones in older infested regions may be found the conditions that may most likely be repeated here in Alabama. In East Texas several counties are now producing more than before the weevil occurred but this fact may be largely explained when we consider that they are principally timbered counties and lumbering, which has heretofore been the most important industry, is now being followed by agriculture. As the timber is removed and with the more favorable seasonal conditions prevailing during the past few years and the higher price paid for cotton, it is but natural that there should be a large increase in cotton acreage and this, with the natural control of the weevil already explained, would entirely account for these increased county yields. Throughout the balance of the territory the 1913 crop would average about 60 per cent of the normal.

The 12-inch to 10-inch zone covers but a very narrow strip in the eastern part of Texas and in Louisiana but expands largely in Southern Arkansas in the territory within the northern range of the weevil. In a majority of these counties, therefore, weevil infestation has never been very severe and we are not surprised to find that the average yield for the past five years shows a slight increase. The tendency appears to be upward in this territory and doubtless still further increase will occur. We should note, however, that Alabama is represented in this zone by only those counties lying north of the Tennessee river. With the light rainfall and winter cold that may naturally be expected in this section, the increased production of cotton in the Tennessee valley would appear entirely possible in spite of the boll weevil.

In the 10-inch to 8-inch zone we find the major portion of the Texas prairie country in which the largest producing counties are situated. Here there is little winter shelter for the weevils, summer control by periods of hot, dry weather is comparatively frequent and the boll weevil is never likely to be serious for any long period of time. In these West Texas counties also, winter cold is likely to be a very important limiting factor. The prevailing conditions here do not occur anywhere in Alabama. In this territory, regardless of latitude, weevil injury will always be slight and increased production entirely feasible. We should bear in mind, however, that recently a variety of the boll

weevil has been discovered in the mountain canyons of Arizona, breeding within the seed pods of a species of plant closely related to cotton but within recent years placed in a different botanical genus. This Arizona insect, known as *Anthonomus grandis,* variety *thurberiae,* has become so accustomed to living in a dry climate and so adapted to a limitation in the number of its generations, due to special conditions of food and drought, that if it should happen, by any chance, to be introduced or to spread into the cotton area of West Texas, it would be likely to become an extremely serious factor in that section, as it is entirely capable of living upon upland cotton as well as upon the host plant upon which it was discovered.

Texas alone is represented in the zone having less than 8 inches of rainfall. In this territory the increase of cotton production has not been as great as in the 10-inch to 8-inch zone. While weevil occurrence is less abundant, the drought is frequently so severe as to limit the production of cotton itself and counties entirely uninfested have been producing during recent years not over four-fifths of their normal crop.

Conclusion.

It is evident from the foregoing that no section of Alabama can hope to escape weevil infestation. In the southernmost counties, cotton production is likely to be greatly decreased within the next few years. It is quite possible, however, even within the 18-inch to 16-inch zone, that some of the best farmers will continue to make fairly good yields of cotton in spite of the weevil but through this territory and in the 16-inch to 14-inch zone as well, it will certainly be very unwise to attempt to maintain an all-cotton system. From the standpoint of better agricultural practices and increased profits, such an attempt would be unwise in any zone, regardless of the presence of the weevil. Cotton can be retained to a large degree and with greater profit in the 14-inch to 12-inch zone than will be possible farther south, but even here some reduction in acreage must be made, advances reduced materially and diversification encouraged.

There is no occasion for panic anywhere in Alabama but this statement is presented to Alabama farmers and business men in order that they may act the more intelligently and without delay.