Factors determining the production areas of each farm commodity in Tennessee

Dalson Henry Esry

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I am submitting herewith a thesis written by Dalson Henry Esry entitled "Factors determining the production areas of each farm commodity in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

C. E. Allred, Major Professor

We have read this thesis and recommend its acceptance:

S. W. Atkins

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)
August 1, 1935.

To the Committee on Graduate Study:

I submit herewith a thesis written by Mr. Dalson H. Esry and entitled "Factors Determining the Production Areas of Each Farm Commodity in Tennessee", and recommend that it be accepted for eighteen quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

[Signature]
Major Professor

At the request of the Committee on Graduate Study, we have read this thesis, and recommend its acceptance.

[Signature]
[Signature]

[Signature]
Accepted by the Committee
Chairman
FACTORS DETERMINING THE PRODUCTION AREAS
OF EACH FARM COMMODITY IN TENNESSEE

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A THESIS

Submitted to the Graduate Committee
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by
DALSON H. ESRY

August 1935
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DALSON H. ESRY.
The purpose of the study made in this manuscript is to assemble and to present in a readily available form the factors that influence the choice of areas where each specific farm commodity of importance is produced or may be produced. An investigator wishing to find out what forces may or may not be favorable to the production of corn may turn to the discussion of corn and find the material already assembled. If he wishes to make a more exhaustive study of a particular factor, the bibliography will aid him in finding the published works in which he might be interested. Without such an aid he would have to examine a great number of publications. It also would be necessary for him to glean the desired material from voluminous discussions of equally interesting and valuable but unrelated topics.

An exhaustive examination and presentation of the factors influencing the production areas of a given farm commodity would require sufficient time and space to be a complete thesis within itself. The desire to thoroughly cover as many of the important commodities as possible in one volume made it necessary to merely mention many of the factors without attempting to completely analyze them. Specialized discussions are already available. The purpose of this study, as previously mentioned, is to assemble the factors of as many commodities as time and space permit.
# Contents

**CHAPTER I. GENERAL FACTORS INFLUENCING PRODUCTION AREAS**  

<table>
<thead>
<tr>
<th>Section</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1.</td>
</tr>
<tr>
<td>Physical Factors</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>4.</td>
</tr>
<tr>
<td>Rainfall</td>
<td>5.</td>
</tr>
<tr>
<td>Elevation</td>
<td>6.</td>
</tr>
<tr>
<td>Soil</td>
<td>6.</td>
</tr>
<tr>
<td>Drainage</td>
<td>7.</td>
</tr>
<tr>
<td>Erosion</td>
<td>8.</td>
</tr>
<tr>
<td>Topography</td>
<td>9.</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>12.</td>
</tr>
<tr>
<td>Market Influences</td>
<td>12.</td>
</tr>
<tr>
<td>Transportation</td>
<td>13.</td>
</tr>
<tr>
<td>Competing Areas</td>
<td>14.</td>
</tr>
<tr>
<td>Localization of Production</td>
<td>14.</td>
</tr>
<tr>
<td>Economic Forces Internal to the Farm</td>
<td>16.</td>
</tr>
<tr>
<td>Governmental Regulations</td>
<td>18.</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>20.</td>
</tr>
<tr>
<td>Insects, Diseases, and Weeds</td>
<td>20.</td>
</tr>
<tr>
<td>Beneficial Factors</td>
<td>21.</td>
</tr>
<tr>
<td>Social Factors</td>
<td>23.</td>
</tr>
<tr>
<td>Characteristics of the People</td>
<td>23.</td>
</tr>
<tr>
<td>Prevailing Community Practices</td>
<td>23.</td>
</tr>
<tr>
<td>Personal Choice</td>
<td>24.</td>
</tr>
<tr>
<td>Summary</td>
<td>25.</td>
</tr>
<tr>
<td>List of Commodities to be Considered</td>
<td>26.</td>
</tr>
<tr>
<td>Cereal Grains</td>
<td>26.</td>
</tr>
<tr>
<td>Legume Crops</td>
<td>27.</td>
</tr>
<tr>
<td>Non Legume Forage Crops</td>
<td>27.</td>
</tr>
<tr>
<td>Other Field Crops</td>
<td>28.</td>
</tr>
<tr>
<td>Livestock</td>
<td>28.</td>
</tr>
<tr>
<td>Truck and Vegetables</td>
<td>28.</td>
</tr>
<tr>
<td>Fruits and Nuts</td>
<td>29.</td>
</tr>
<tr>
<td>Ornamental Plants</td>
<td>30.</td>
</tr>
<tr>
<td>Forest Products</td>
<td>31.</td>
</tr>
<tr>
<td>Game and Fur</td>
<td>31.</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>32.</td>
</tr>
<tr>
<td>Bibliography</td>
<td>33.</td>
</tr>
</tbody>
</table>
CHAPTER IX. CEREAL CROPS

<table>
<thead>
<tr>
<th>Crop</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>34</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>35</td>
</tr>
<tr>
<td>Rainfall</td>
<td>36</td>
</tr>
<tr>
<td>Soil</td>
<td>40</td>
</tr>
<tr>
<td>Topography</td>
<td>41</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>42</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>45</td>
</tr>
<tr>
<td>Social Factors</td>
<td>45</td>
</tr>
<tr>
<td>Regional Cost of Production</td>
<td>45</td>
</tr>
<tr>
<td>Wheat</td>
<td>47</td>
</tr>
<tr>
<td>Physical Factors</td>
<td>47</td>
</tr>
<tr>
<td>Climatic Adaptations</td>
<td>47</td>
</tr>
<tr>
<td>Soil</td>
<td>49</td>
</tr>
<tr>
<td>Topography</td>
<td>50</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>50</td>
</tr>
<tr>
<td>Regional Differences by Types</td>
<td>52</td>
</tr>
<tr>
<td>Hard Red Winter Wheat</td>
<td>52</td>
</tr>
<tr>
<td>Hard Red Spring Wheat</td>
<td>55</td>
</tr>
<tr>
<td>Durum Wheat</td>
<td>56</td>
</tr>
<tr>
<td>Soft Red Winter Wheat</td>
<td>57</td>
</tr>
<tr>
<td>Oats</td>
<td>59</td>
</tr>
<tr>
<td>General Adaptations</td>
<td>59</td>
</tr>
<tr>
<td>Climate</td>
<td>60</td>
</tr>
<tr>
<td>Soil</td>
<td>61</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>61</td>
</tr>
<tr>
<td>Fall-sown Oat Production</td>
<td>64</td>
</tr>
<tr>
<td>Barley</td>
<td>67</td>
</tr>
<tr>
<td>Competition with Oats</td>
<td>67</td>
</tr>
<tr>
<td>Causes of Small Barley Acresage</td>
<td>70</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>71</td>
</tr>
<tr>
<td>Soil</td>
<td>71</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>71</td>
</tr>
<tr>
<td>Winter Barley</td>
<td>72</td>
</tr>
<tr>
<td>Rye</td>
<td>73</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>74</td>
</tr>
<tr>
<td>Soils</td>
<td>75</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>75</td>
</tr>
<tr>
<td>Grain Sorghums</td>
<td>79</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>79</td>
</tr>
<tr>
<td>Soils</td>
<td>80</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>80</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>81</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>82</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>82</td>
</tr>
<tr>
<td>Soil</td>
<td>82</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>83</td>
</tr>
<tr>
<td>Danger of Complete Loss</td>
<td>83</td>
</tr>
<tr>
<td>Chapter</td>
<td>Title</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>III</td>
<td>LEGUME CROPS</td>
</tr>
<tr>
<td></td>
<td>Alfalfa</td>
</tr>
<tr>
<td></td>
<td>Climatic Factors</td>
</tr>
<tr>
<td></td>
<td>Rainfall</td>
</tr>
<tr>
<td></td>
<td>Altitude and Soils</td>
</tr>
<tr>
<td></td>
<td>Drainage</td>
</tr>
<tr>
<td></td>
<td>Economic Factors</td>
</tr>
<tr>
<td></td>
<td>Biological Factors</td>
</tr>
<tr>
<td></td>
<td>Sweet Clover</td>
</tr>
<tr>
<td></td>
<td>Climatic Factors</td>
</tr>
<tr>
<td></td>
<td>Soil Requirements</td>
</tr>
<tr>
<td></td>
<td>Economic Factors</td>
</tr>
<tr>
<td></td>
<td>Red Clover (Medium)</td>
</tr>
<tr>
<td></td>
<td>Climatic Factors</td>
</tr>
<tr>
<td></td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td>Economic Factors</td>
</tr>
<tr>
<td></td>
<td>Biological Factors</td>
</tr>
<tr>
<td></td>
<td>Mammoth Clover</td>
</tr>
<tr>
<td></td>
<td>Alake Clover</td>
</tr>
<tr>
<td></td>
<td>Substitute for Red Clover</td>
</tr>
<tr>
<td></td>
<td>Climate</td>
</tr>
<tr>
<td></td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td>Economic Factors</td>
</tr>
<tr>
<td></td>
<td>Biological Factors</td>
</tr>
<tr>
<td></td>
<td>Crimson Clover</td>
</tr>
<tr>
<td></td>
<td>Climatic Factors</td>
</tr>
<tr>
<td></td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td>Economic Factors</td>
</tr>
<tr>
<td></td>
<td>White Clover</td>
</tr>
<tr>
<td></td>
<td>Climatic Factors</td>
</tr>
<tr>
<td></td>
<td>Soils</td>
</tr>
<tr>
<td></td>
<td>Economic Factors</td>
</tr>
<tr>
<td></td>
<td>Bur Clover</td>
</tr>
<tr>
<td></td>
<td>Climatic Factors</td>
</tr>
<tr>
<td></td>
<td>Soils</td>
</tr>
<tr>
<td></td>
<td>Economic Factors</td>
</tr>
<tr>
<td></td>
<td>Lespedeza</td>
</tr>
<tr>
<td></td>
<td>Climatic and Soil Factors for Common Lespedeza</td>
</tr>
<tr>
<td></td>
<td>Economic Factors of Common Lespedeza</td>
</tr>
<tr>
<td></td>
<td>Korean Lespedeza</td>
</tr>
<tr>
<td></td>
<td>Lespedeza sericea</td>
</tr>
<tr>
<td>Topic</td>
<td>Pages</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Vetches</td>
<td>124.</td>
</tr>
<tr>
<td>Common Vetch</td>
<td>124.</td>
</tr>
<tr>
<td>Climatic and Soil Factors</td>
<td>124.</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>126.</td>
</tr>
<tr>
<td>Hairy Vetch</td>
<td>126.</td>
</tr>
<tr>
<td>Soy Bean</td>
<td>127.</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>129.</td>
</tr>
<tr>
<td>Soils</td>
<td>129.</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>130.</td>
</tr>
<tr>
<td>The Soy Bean as a Grain Crop</td>
<td>132.</td>
</tr>
<tr>
<td>Other Uses</td>
<td>134.</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>134.</td>
</tr>
<tr>
<td>Cowpeas</td>
<td>135.</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>135.</td>
</tr>
<tr>
<td>Soils</td>
<td>135.</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>137.</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>138.</td>
</tr>
<tr>
<td>Peanuts</td>
<td>139.</td>
</tr>
<tr>
<td>Climate</td>
<td>139.</td>
</tr>
<tr>
<td>Soils</td>
<td>139.</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>140.</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>141.</td>
</tr>
<tr>
<td>Velvet Bean</td>
<td>141.</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>141.</td>
</tr>
<tr>
<td>Soils</td>
<td>141.</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>143.</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>143.</td>
</tr>
<tr>
<td>Field Pea</td>
<td>144.</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>144.</td>
</tr>
<tr>
<td>Soils</td>
<td>144.</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>146.</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>146.</td>
</tr>
<tr>
<td>Bibliography</td>
<td>147.</td>
</tr>
<tr>
<td><strong>CHAPTER IV. NON-LEGUM FORAGE CROPS</strong></td>
<td>150.</td>
</tr>
<tr>
<td>Timothy</td>
<td>150.</td>
</tr>
<tr>
<td>Climatic Adaptations</td>
<td>150.</td>
</tr>
<tr>
<td>Soil Requirements</td>
<td>151.</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>151.</td>
</tr>
<tr>
<td>Timothy for Pasture</td>
<td>152.</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>153.</td>
</tr>
<tr>
<td>Kentucky Bluegrass</td>
<td>155.</td>
</tr>
<tr>
<td>Climatic Adaptations</td>
<td>155.</td>
</tr>
<tr>
<td>Soil Requirements</td>
<td>158.</td>
</tr>
<tr>
<td>Affects of Drought</td>
<td>158.</td>
</tr>
<tr>
<td>Value as a Permanent Pasture Grass</td>
<td>158.</td>
</tr>
<tr>
<td>Grass Type</td>
<td>Physical Factors</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Canada Bluegrass</td>
<td></td>
</tr>
<tr>
<td>Bermuda Grass</td>
<td></td>
</tr>
<tr>
<td>Redtop</td>
<td></td>
</tr>
<tr>
<td>Carpet Grass</td>
<td></td>
</tr>
<tr>
<td>Johnson Grass</td>
<td></td>
</tr>
<tr>
<td>Orchard Grass</td>
<td></td>
</tr>
<tr>
<td>Italian Ryegrass</td>
<td></td>
</tr>
<tr>
<td>Sudan Grass</td>
<td></td>
</tr>
<tr>
<td>Forage Sorghums</td>
<td></td>
</tr>
<tr>
<td>Millet</td>
<td></td>
</tr>
<tr>
<td>Reed Canary Grass</td>
<td></td>
</tr>
<tr>
<td>Title</td>
<td>Pages</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Chapter V, Other Field Crops</td>
<td>190</td>
</tr>
<tr>
<td>Cotton</td>
<td>190</td>
</tr>
<tr>
<td>Climatic Adaptations</td>
<td>191</td>
</tr>
<tr>
<td>Seasonal Climatic Requirements</td>
<td>191</td>
</tr>
<tr>
<td>Soil Requirements</td>
<td>194</td>
</tr>
<tr>
<td>The Ideal Soil</td>
<td>195</td>
</tr>
<tr>
<td>Other Soil Conditions</td>
<td>196</td>
</tr>
<tr>
<td>Topography</td>
<td>196</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>197</td>
</tr>
<tr>
<td>Necessity of Cheap Labor</td>
<td>197</td>
</tr>
<tr>
<td>Supply and Demand Influences Upon</td>
<td></td>
</tr>
<tr>
<td>Production Areas</td>
<td>198</td>
</tr>
<tr>
<td>Competitive Crops</td>
<td>200</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>202</td>
</tr>
<tr>
<td>Mexican Boll Weevil</td>
<td>202</td>
</tr>
<tr>
<td>Other Cotton Insects</td>
<td>203</td>
</tr>
<tr>
<td>Cotton Diseases</td>
<td>205</td>
</tr>
<tr>
<td>Social Factors</td>
<td>204</td>
</tr>
<tr>
<td>Flax</td>
<td>205</td>
</tr>
<tr>
<td>General Soil and Climatic Factors</td>
<td>205</td>
</tr>
<tr>
<td>Climatic Conditions for Fiber Flax</td>
<td>206</td>
</tr>
<tr>
<td>Soil Requirements of Fiber Flax</td>
<td>207</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>208</td>
</tr>
<tr>
<td>Biological Factors</td>
<td>210</td>
</tr>
<tr>
<td>Tobacco</td>
<td>211</td>
</tr>
<tr>
<td>Areas of Tobacco Production</td>
<td>211</td>
</tr>
<tr>
<td>Classes and Types of Tobacco</td>
<td>211</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>212</td>
</tr>
<tr>
<td>Soil Requirements</td>
<td>213</td>
</tr>
<tr>
<td>Topography</td>
<td>216</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>216</td>
</tr>
<tr>
<td>Expansion of Tobacco Acreage to Meet Price Increases</td>
<td>217</td>
</tr>
<tr>
<td>Adaptability of Tobacco to Cropping Systems</td>
<td>218</td>
</tr>
<tr>
<td>Diseases Affecting Tobacco Production</td>
<td>220</td>
</tr>
<tr>
<td>Insects Affecting Tobacco Production</td>
<td>222</td>
</tr>
<tr>
<td>Social Factors</td>
<td>223</td>
</tr>
<tr>
<td>Irish or White Potatoes</td>
<td>224</td>
</tr>
<tr>
<td>Climatic Adaptations</td>
<td>224</td>
</tr>
<tr>
<td>Soil Requirements</td>
<td>233</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>235</td>
</tr>
<tr>
<td>Potato Diseases</td>
<td>234</td>
</tr>
<tr>
<td>Insect Pests</td>
<td>236</td>
</tr>
<tr>
<td>Social Factors</td>
<td>237</td>
</tr>
<tr>
<td>Chapter VI. LIVESTOCK</td>
<td>Pages</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Introduction</td>
<td>254.</td>
</tr>
<tr>
<td>Influences of Density of Population</td>
<td>254.</td>
</tr>
<tr>
<td>Physical Factors</td>
<td>256.</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>257.</td>
</tr>
<tr>
<td>Beef Cattle</td>
<td>258.</td>
</tr>
<tr>
<td>Breeding and Rearing Calves</td>
<td>258.</td>
</tr>
<tr>
<td>Growing of Stockers</td>
<td>262.</td>
</tr>
<tr>
<td>Fattening Cattle for Market</td>
<td>264.</td>
</tr>
<tr>
<td>Baby Beef Production</td>
<td>267.</td>
</tr>
<tr>
<td>Dual-purpose Cattle</td>
<td>268.</td>
</tr>
<tr>
<td>Purebred Cattle</td>
<td>270.</td>
</tr>
<tr>
<td>Adaptability of the Beef Breeds</td>
<td>272.</td>
</tr>
<tr>
<td>Dairy Cattle</td>
<td>275.</td>
</tr>
<tr>
<td>Economic Position in a Permanent Agriculture</td>
<td>276.</td>
</tr>
<tr>
<td>Factors Influencing Dairy Production Areas</td>
<td>277.</td>
</tr>
<tr>
<td>Feeds Necessary for Dairy Cattle</td>
<td>278.</td>
</tr>
<tr>
<td>Housing and Temperature Requirements</td>
<td>279.</td>
</tr>
<tr>
<td>Social Factors Influencing Dairying</td>
<td>280.</td>
</tr>
<tr>
<td>Other Economic Factors</td>
<td>281.</td>
</tr>
<tr>
<td>Milk Produced for Fluid Consumption</td>
<td>282.</td>
</tr>
<tr>
<td>Butter Production</td>
<td>284.</td>
</tr>
<tr>
<td>Cheese Production</td>
<td>287.</td>
</tr>
<tr>
<td>Other Dairy Products</td>
<td>288.</td>
</tr>
<tr>
<td>Purebred Breeding Herds</td>
<td>289.</td>
</tr>
<tr>
<td>Factors Influencing Breeds</td>
<td>289.</td>
</tr>
<tr>
<td>Table</td>
<td>Title</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>I</td>
<td>Correlation of Rainfall and the Yields of Corn for Indiana, Illinois, Iowa, and Missouri</td>
</tr>
<tr>
<td>II</td>
<td>The July Rainfall and the Yield of Corn in Tennessee (1898-1934)</td>
</tr>
<tr>
<td>III</td>
<td>Average Acreage and Yields of Barley and Oats with the Calculation of Total Digestible Nutrients in 55 states, 1922, 1923, 1924</td>
</tr>
<tr>
<td>IV</td>
<td>Comparison of Sudan Grass with Millet and Sorgho in Yields Per Acre of Cured Hay</td>
</tr>
<tr>
<td>V</td>
<td>Comparison of Corn and Sorghum for Silage Purposes</td>
</tr>
<tr>
<td>VI</td>
<td>A Comparison of Yields of Sorgho, Corn, and Kafir for Silage on Rich Soil at Manhattan, Kansas</td>
</tr>
<tr>
<td>VII</td>
<td>Correlation of the Mean Temperature For Different Periods With the Potato Yield in Ohio, (1860-1914)</td>
</tr>
<tr>
<td>VIII</td>
<td>Correlation between the Yield of Potatoes and the Mean July Temperature in Tennessee</td>
</tr>
<tr>
<td>IX</td>
<td>Correlation Between the Yield of Potatoes and the July Precipitation in Tennessee</td>
</tr>
<tr>
<td>X</td>
<td>Correlation of the Rainfall for Different Periods with the Potato Yield in Ohio, for 1860 to 1914</td>
</tr>
<tr>
<td>XI</td>
<td>Influence of Percentages of Water in Soil and Temperatures of Soil Upon the Disease Resistance of Potato Plant</td>
</tr>
<tr>
<td>XII</td>
<td>Human Food Produced Annually From an Acre of Land Utilized as Various Food Products</td>
</tr>
<tr>
<td>XIII</td>
<td>Relation of Corn to Hog Production, 1929</td>
</tr>
<tr>
<td>FIGURES</td>
<td>Pages</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>1. Map showing the acreage in corn in the United States, 1929</td>
<td>35</td>
</tr>
<tr>
<td>2. Relation between the July rainfall and the Yield of corn in</td>
<td>36</td>
</tr>
<tr>
<td>Tennessee, 1898 - 1934</td>
<td></td>
</tr>
<tr>
<td>3. The Uses of corn harvested for grain in the United States, based</td>
<td>43</td>
</tr>
<tr>
<td>on estimates by the United States Department of Agriculture</td>
<td></td>
</tr>
<tr>
<td>4. Regional variations in the cost of producing corn</td>
<td>46</td>
</tr>
<tr>
<td>5. Distribution of wheat in the United States in 1929</td>
<td>53</td>
</tr>
<tr>
<td>6. Distribution of hard red winter wheat in the United States, 1919</td>
<td>53</td>
</tr>
<tr>
<td>7. Distribution of hard red spring wheat in the United States, 1919</td>
<td>56</td>
</tr>
<tr>
<td>8. Distribution of the oat acreage in the United States, 1919</td>
<td>59</td>
</tr>
<tr>
<td>9. The distribution of Red Rustproof oats in the United States, 1919</td>
<td>60</td>
</tr>
<tr>
<td>10. Distribution of spring oat varieties in the United States, 1919</td>
<td>63</td>
</tr>
<tr>
<td>11. Fall-sown oats in Southeastern United States</td>
<td>64</td>
</tr>
<tr>
<td>12. Barley production in the United States in 1919</td>
<td>67</td>
</tr>
<tr>
<td>13. Regions in the United States with a climate relatively favorable</td>
<td>70</td>
</tr>
<tr>
<td>to barley</td>
<td></td>
</tr>
<tr>
<td>14. Rye production in the United States in 1929</td>
<td>73</td>
</tr>
<tr>
<td>15. Plots of spring wheat, winter rye, and winter wheat in</td>
<td>74</td>
</tr>
<tr>
<td>Western South Dakota</td>
<td></td>
</tr>
<tr>
<td>17. Acreage of timothy and clover mixed in the United States, 1919</td>
<td>102</td>
</tr>
<tr>
<td>18. Area of severe anthracnose trouble in Eastern United States</td>
<td>106</td>
</tr>
<tr>
<td>19. Area in which alsike clover is grown in the United States</td>
<td>108</td>
</tr>
<tr>
<td>20. Ability of alsike clover to endure water</td>
<td>109</td>
</tr>
<tr>
<td>21. Regions in the United States where crimson clover is most</td>
<td>111</td>
</tr>
<tr>
<td>widely grown</td>
<td></td>
</tr>
</tbody>
</table>
22. A crimson clover failure on ground too poor in humus . . . . 113.
23. Regions of the United States to which bur clover is adapted . 117.
24. Approximate northern and western range of annual lespedezeas
in the United States . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .119.
25. Regions suited to the fall seeding of common vetch . . . . . 124.
26. Areas of the United States in which the soybean is especially
adapted . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 128.
30. Average dates of the last killing frost in the spring and the
first killing frost in the fall. (Influence on velvet bean
production) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 142.
31. Areas of the United States to which the field pea is well
adapted . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 144.
32. Boundaries of the principal grain-sorghum and forage-sorghum
areas of the United States . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 177.
33. Region of the United States to which Reed Canary Grass is
adapted . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 185.
34. The production of cotton in the United States in 1924 . . . . . 190.
35. Flax acreage in the United States according to the Census
of 1909 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .206.
36. Environmental influence on form of tuber of Green Mountain
variety . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 232.
37. Environmental influence on form of tuber of Irish Cobbler
variety . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 232.
38. Areas in the United States in which sweetpotatoes are grown . 238.
39. Relation of corn to Hog Production, 1929 . . . . . . . . . . . . . 297.
CHAPTER I.

GENERAL FACTORS INFLUENCING PRODUCTION AREAS.

1. Introduction.

The business of the agricultural industry is to produce profitably crops and livestock. This production demands definite materials in sufficient quantities and favorable combinations if the enterprises are to be carried on economically. A furniture maker must have lumber, screws, and paint; an ample supply of power, labor and factory space; and a market large enough to absorb his output. The farmer's business is no different in its general demands. He needs seed, fertilizer, and other working materials; he needs land, labor, capital and management; and he needs a ready outlet for his produce. The primary difference between the farmer and the furniture maker is in the combination of the things with which they work.

A possible third set of conditions dealing with the power of the
farm to produce wealth are those that determine the value of this wealth;
that is, available markets, price conditions, and transportation are the
forces that place an actual value onto the produced wealth. Huge quanti-
ties of goods may be produced by the combination of the forces of nature
and the guiding hand of man, but unless the economic forces that place a
value on the goods are present, the efforts of the producer are wasted
and the goods are of no immediate interest to the consumer. The produc-
tion of wealth in physical quantities, therefore, is the ultimate result
of the available factors of production, and the value of this wealth is
measured by the economic forces existing under the given circumstances.

The commodities produced in any area often appear to be the result
of a haphazard growth; but in reality certain definite forces, which may
be classed as physical, economic, biological, and social, work in varying
combinations and in any number of proportions in each combination to give
origin to a prevailing type of agriculture. The physical factors can be
said to determine the crops that can be successfully grown in a community;
these in turn affect the livestock enterprises best adapted to the area.
The economic and biological factors help to determine not only the com-
modities that will be produced, but the relative amounts of each and the
way they will be marketed. Each commodity has its special set of re-
quirements which must be met if it is to be produced economically.

2. Roth, Walter C., Types of Farming in Kentucky, Unpublished Manuscript.
3. Case, H. C. M. and Myers, K. C., Types of Farming in Illinois,
Illinois Experiment Station Bulletin 403, P. 118.
The limiting influence of a given factor is only absolute in its extreme state. Within the limits of this extreme state, the influence of the factor is reduced to a condition whereby other factors combine with it in varying proportions according to the existing situation. The northern limit of cotton production is rather definitely set by the length of the growing season, yet this limit is rarely reached. Other factors combine with the length of the growing season in relatively greater degrees of influence as the length of the growing season nears its more favorable condition. The weight of each factor cannot be definitely stated, for it depends upon how close it is to its own limiting boundaries and upon how close the other forces are to their optimum condition. It can be generally stated, however, that the relative degree of influence of a factor tends to increase as the distance from its optimum condition increases if all other factors are held constant.

A knowledge of the way these factors work and of the individual requirements of the farm commodities is necessary before a farmer can successfully plan his operations. Black makes the following statement:

"The final objective in an economic analysis of production is to choose and combine the products and production elements in terms of their values or prices. The right combination is the one which secures the most economical utilization of all the elements."

The science of production, therefore, is largely a science of combination. The farmer either deliberately or unconsciously strives to reach a perfect balance of the existing or available factors in his farming operations. He knows that it is useless to try to raise cotton if the growing season is short. His choice must be of an enterprise for which the most ideal conditions exist.

II. Physical Factors.

The physical factors usually draw the absolute limits of the large general production areas. Within these boundaries all of the factors are balanced into varying combinations. Climate, soil, and topography are the physical factors. Warren makes the following statement:

These physical conditions are the most important factors in determining the type of farming, but it is the combination of these with many other factors that settles the matter. The other factors may be so important as to result in a type of farming very different from what the physical facts suggest.

Temperature. The temperature during the growing season must be within a definite range. Many plants thrive where the mean temperature is low; others need a much higher level. Some crops cannot endure extreme heat for even a short time; others are injured by frosts. Prolonged coolness or heat during the growing season is also harmful to some crops. Closely associated to temperature is the length of the growing season. It must be long enough to give the crop reasonable time to mature. This is normally determined by the time between the last frost in the spring and the first one in the fall.

The effects of temperature is less apparent as a primary limitation upon livestock production, but it must invariably be considered. Livestock, like all living things, is injured by extreme temperatures and does best under optimum conditions. The temperature limitations upon feed crops are secondary limitations upon livestock, because an available feed supply is essential for economical livestock production.

5. Warren, G. F., Farm Management, P. 44.
A third influence of temperature is that of the length and severity of the winter. The shorter pasture seasons, greater demand for care, and the necessity for more expensive winter housing facilities add much to the cost of livestock in regions of long, severe winters.

Rainfall. Rainfall plays an important part in limiting the production areas of practically all plants. Some crops need only a small annual rainfall and others demand much. The seasonal nature rather than the total amount of the rainfall is often the determining factor. A limited amount falling in an opportune time will permit the production of a crop, but the same amount or even a greater amount poorly distributed gives an entirely different situation. A large rainfall at the wrong time can be as much of a limiting factor as a scarcity of rain. Such a condition could interfere with essential cultural practices, could cause improper maturity, or could cause floods to destroy entirely crops of the inundated regions. Many crops demand rain-free days to grow properly. Extremely long periods of cloudiness interferes with proper photosynthesis.

The annual or seasonal amount of rainfall may not be as important as the amount which is effective. The amount of run-off and evaporation determines what part of the seasonal supply will be available to the crops. Evaporation is higher in regions of dry atmosphere. Four factors influence the rate of run-off; the topography of the region, the physical character of the soil, the character of the soil covering (plant growth), and the amount and rate of fall of the rain each partially control the rate of run-off. 6

Some plants are easily damaged by drouthy conditions and cannot be economically grown in areas susceptible to frequent drouths.

Elevation. Elevation affects production areas by influencing the climate. Cold nights and low humidity are associated with high altitudes. The growing season may be shorter and the mean temperature is often lower.

Soil. The influence of soil is widespread in some instances and local in others. Soil conditions often can be altered by appropriate cultural practices to suit the needs of a crop, providing the income from the crop will pay for the added expense, but the soil more naturally suitable has a distinct advantage.

The physical type of the soil is quite important to some plants. Vegetables are more easily handled on sandy soils; the cereals do best on finer types such as a clay loam. The water holding capacity, the friability, and the aeration of the soil differs with different soil types. Plant requirements vary greatly in the optimum type of soil and in the range of relatively suitable types.

Soils containing a high natural fertility usually hold a distinct advantage over the less fertile ones. Some crops, however, make a more desirable growth on less fertile soils. Fertility can be altered by the addition of fertilizers or manures and by including certain crops such as legumes in the rotation. The plant food elements usually present in a limited supply are nitrogen, calcium, phosphorous, and potassium.

The organic matter or humus present in the soil affects both the fertility and the physical state of the soil. The water holding capacity of a sandy soil and the friability of a tight or compact soil are increased by the presence of organic matter. The plant food elements, especially nitrogen, are available in greater amounts and in more accessible forms in soils of a high organic matter content.
Soils containing high organic matter are not only more easily tilled and of higher fertility, but they also remain in a relatively fertile state for several years under adverse conditions. This greater permanence makes possible a more exhaustive cropping system. Corn, for instance, can be grown more often in the rotation than it could if more care were necessary to keep the soil in a high state of productivity. A soil ideally adapted, but with no natural reserve, can only temporarily be an important factor attracting the production of a commodity.

Many plants cannot grow upon acid soils, or if they can, their production is of an inferior nature. The amount of rainfall affects soil acidity, for the limestone soils lose much of their calcium content through leaching.

There is a very wide range in the response of various crops to soil acidity. Professor Truog of Wisconsin conducted experiments to determine the lime requirements of the more common plants. Nine degrees of lime requirement are recognised, and are designated as follows, going from the lowest to the highest requirement:

1. Very low
2. Very low plus
3. Low
4. Low plus
5. Medium
6. Medium plus
7. High
8. High plus
9. Very high

Drainage. Drainage is an important problem in many communities. Of course the rolling land is naturally drained, but its importance cannot be overlooked in low, level areas. Surface drainage is necessary to keep water from standing in the fields. Rice can stand and really demands

flooded lands. Many plants do not do well where the water table level is high. Many failures of alfalfa are caused by water logged soils or by a high water table. The physical type of the soil often influences the degree to which it is water logged.

Air drainage must be considered in locating orchards. Valleys are not well adapted to orchards in the regions of cold winters, because cold air settles to the lower land.

Erosion. An ever increasing interest is being taken in the choice of crops from an erosion standpoint. The early settlers made no attempts to check the loss of soil through washing, but this great depletion of natural fertility is gaining recognition as a serious and a permanent problem. Cultivated crops or crops that offer no winter protection to the soil cannot be continuously grown on rolling land without severe losses. The rolling land should be in non-cultivated crops a greater part of the time. Winter cover crops will keep down the winter loss. Land that is exceptionably susceptible to washing is best handled by permanently keeping it in sod crops. Extreme cases demand the use of forest trees and will yield more as forests than otherwise over a period of years.

Rye, vetch, and the clovers are possible winter cover crops that are helpful in reducing surface washing. Some attempt should be made to include them in the rotation. Soils that are gullying badly can be put into relatively permanent sods such as bluegrass. Livestock farming tends to go along with crop control of erosion, because the increased acreage of soils and of winter cover crops makes available more pasture than a strictly cultivated crop type of rotation. The use of large, efficient power units in the farming operations are more easily adapted to flat than to rolling, badly eroded fields. This is another reason for keeping eroded regions in sod crops that can be harvested by livestock.
Topography. Topography is the third major physical factor determining the production areas of farm commodities. Level land is much more adaptable to the use of large machine and power units than is more rolling or hilly land. Fields that are necessarily irregular in shape or that are rough are expensive to till. A grazing crop marketed through livestock is more easily handled on uneven, broken land than in a cultivated grain crop. Crops adapted to extensive production demand that field operations be performed economically. Wheat and combine-harvesters, corn and multi-rowed cultivating units, and other similar extensive operations are possible only on the less rolling lands. In addition to the direct affect of topography upon the production areas of the various commodities, topography has a secondary importance in its influence upon climate, drainage, erosion, and soil fertility.

Mountain ranges broadly influence the rainfall and the temperature of neighboring regions. Crops demanding cool weather can be grown at high altitudes in the warmer parts of the country. One side of a high mountain range may have a high rainfall, but the other side often is quite arid.

The effect of topography upon drainage is serious in both hilly and level regions. One farmer has slopes with which to contend. His crop production must be built from an erosion control point of view. The farmer on lowlands and other level areas must contend with ponds, floods, dredge ditches, and other similar drainage problems. If his land is flooded annually, if his farm contains low marshy areas hard to drain in wet seasons, or if the water-table level of his soil is exceptionally high his choice of crops must be made to meet the particular situation.

There is considerable relationship between soil fertility and topography and rainfall. The original grasslands of the United States have a moderately low rainfall as compared with the timber areas. Furthermore, the grasslands are generally level, and a large part of the woodlands are rolling or hilly. Soils originally or at present covered with forest are normally light colored; grassland soils, in general, are dark colored. Lighter soils are less fertile because of the lack of organic matter as indicated by the color of the soil.

The level grassland soils are less subject to erosion and to leaching. A lower rainfall, the level nature of the land, and the soil cover all tend to cause less washing and leaching than is common in the steeper timber areas of higher rainfall. Erosion carries off the top layers of soils which contain the organic matter deposited by decaying plants. The minerals made available to the plants by the decomposition and disintegration processes are also near the surface and are swept away from eroding surfaces. A raw, partially decomposed soil that contains little or no organic matter is left behind.

Alluvial soils of the timber regions are quite fertile because erosion has removed the most fertile part of the uplands and has deposited it on the level flood plains. Here again a level land is more fertile than the rolling land nearby.

Glaciated areas generally have good, fertile soils. The plant food elements have not been removed by leaching to the extent of that of residual soils. Continental glaciation has leveled out the topography of the regions over which the ice sheet passed.

10. Emerson, Frederick W., Agricultural Geology, P. 235.
The resulting flat or gently rolling areas are favorable to the accumulation of humus and are adaptable to extensive farming operations. The deep layers of finely ground soil particles provide a well adapted agricultural soil. Drainage problems are more serious on the extensive level areas.

Glaciation itself is not a factor determining production areas, but its alteration of soil and topography is of great importance as a force behind the recognized factors.

Many of the physical factors affecting production areas of farm commodities are not present in Tennessee; yet their influence is profound because of the handicap or the advantage they give to competing areas. Continental glaciation never reached Tennessee, but the Corn Belt largely received its vast acreage of fertile, level land from the glacier. The Tennessee farmers cannot equally compete with the Iowa corn and hog producers.
III. Economic Factors.

The Importance of economic factors in determining production areas of farm commodities has greatly increased as agriculture has developed from a self-sufficing state to that of a highly competitive commercial industry. The most profitable combination of enterprises on the farm is influenced by the competition between areas and the competition or interdependence of enterprises on the farm. 11

Market Influences. The market affects the production areas of a commodity in two major ways. It must furnish a sufficient potential demand to absorb a reasonable supply of the product, and it must be available to the production area in question.

The price that the farmer will receive for his product is determined by the interaction of supply and demand. He will normally produce the commodities that will return to him the largest income over a period of years. If land is relatively cheap and the physical factors are favorable, extensive enterprises for which he has a profitable market, such as grain farming or livestock grazing, will make up his business. If a city should spring up nearby, there will be a large potential demand for dairy and truck products. These enterprises will develop not because of any local physical advantages but because they are profitable enough to gain first choice. Land values will increase because of this higher income. Then the area must produce the more intensive commodities to pay for the land.

The demand for intensive products resulted in higher land values; then higher land values demand that intensive products be produced to meet the increased costs of production. The farmer, either consciously or unconsciously strives to reach the balance more favorable to him. If this balance is such that the price received is generally below the prevailing cost of production for the area, this area will not produce a large amount of the given commodity.

Transportation. The potential demand for a product may be great, and the local physical conditions may be conducive to the economical production of a commodity; but there must be some means of spanning the gap between the producer and the consumer. Adequate marketing machinery to carry out the functions of concentration, standardization, and dispersion is necessary. A dairy farmer who peddles his own milk performs all of these functions. The wheat farmer has to depend upon an intricate marketing structure starting with the local dealer and including transportation facilities, financial institutions, wholesale dealers, milk, jobbers, and retail stores. Both farmers are affected by the availability of their market. If the dairyman's market is too far away he cannot afford to haul his milk to it, and if there is no country shipping point within a reasonable distance from the wheat farmer he has difficulty in profitably disposing of his wheat.

The available transportation facilities often play an important part in the location of production areas. Bulky products demand cheap transportation; perishable products must be moved quickly. Refrigeration is often necessary. Efficient loading facilities must be available. The quantity of a commodity produced in a given area must be sufficiently large to warrant economical assembling and efficient loading and carrying facilities.
Competing Areas. Another factor to be considered is the availability of the market to competing areas. This is in reality a phase of the problem of favorably balancing the supply and demand. The area closer to the market usually has the advantage of cheaper transportation, but this is not always true; cheaper forms of transportation such as waterways can often be used to bring distant areas in competition with those close by.

The per unit value of the commodity influences the relative importance of transportation costs upon the determination of production areas. Butter-fat can be shipped a long distance, but hay cannot; transportation costs make up a very small part of the ultimate price of the farmer, but a major part of the price paid by the hay consumer on hay shipped long distances is freight.

Market conditions are continuously changing. Shifts in the supply and demand balance, additions to or changes in transportation and handling methods, and relative price movements which vary the ratio of market costs to other costs may cause profound changes in the production areas of farm commodities.

Localization of Production. The localization of production with reference to the market or consuming center is summarised in Von Thuenen's Law. Von Thuenen was a German economist who first pointed out this principle some one hundred years ago. Holmes states the principle in two parts as follows:

1. Goods which are of low specific value tend to be produced adjacent to the marketing or consuming center, while those of higher specific value are produced at greater distances, and those with the maximum specific value at maximum distances from the market.

II. Goods of a high degree of perishability tend to be produced adjacent to the market, those of a less degree of perishability at a greater distance, and those which are of high durability at the maximum distance from the market.

Transportation is the force largely behind this principle, and as new methods of transportation, refrigeration, and storage are employed, entirely new situations result. The shipment of highly perishable vegetables from the Gulf States to large cities, such as New York and Chicago, is an alteration of Von Thuenen's law made possible by modern developments.

Farm commodities for which conditions are less ideal, but which are profitable enough to demand consideration are often produced in certain areas. This is a case in which the demand as portrayed in price is sufficient to counterbalance all the more adverse conditions of the commodity and all the advantages afforded the competing enterprises. Two corresponding situations are given by Case and Myers. They are:

1. One area may hold a potential advantage over another area in the production of a certain commodity, it may not produce that commodity because of the greater advantage it has in the production of other commodities.

2. An area, because there is no product that will fit into its farming scheme and return a better income, may be forced into the production of some crops in direct competition with areas that have superior advantages for those crops.

One area may be more adapted to cotton production than another, yet the latter will produce more cotton because the former can more profitably raise truck or dairy products than it can cotton. One area poorly adapted to corn may produce much corn in competition with areas more favorably adapted merely because its disadvantages to corn are less than those to cotton, tobacco and other crops.

Economic Forces Internal to the Farm. The economic forces internal to the farm are those which deal with the relationship of one enterprise to another on the farm. These forces are the ones that the farmer employs to give his business harmony and to fully utilize the elements of production available to him. Taylor, in his discussion of the factors the farmer must consider in organizing his resources to get the most profitable utilization of his land, labor, and equipment, classifies the factors as competitive, supplementary, and complementary relationships.

The seasonal power and labor distribution varies with different crops and with different livestock enterprises. Corn, cotton and tobacco conflict with each other for labor and power, and if a farmer attempts to include all three in his rotation, he will discover that he is very busy one season and idle the next. Such enterprises as these are known as competing enterprises.

The farmer could accomplish far more if he would select crops for which the demands of labor and power dovetail. Perhaps some small grain could be substituted for a part of the cultivated crop acreage. Consider that it takes six horses and one man to care for eighty acres of corn, but they are idle in early March and in July. A field of oats could be added with little or no increase of power and labor costs except at harvest time. This same man could care for a few sows thus utilizing more of his time. A car load of feeder cattle could be fed during the winter months in an attempt to use profitably this vast amount of spare time. Such enterprises, making possible a fuller use of the available elements of production, are supplementary enterprises.

The complementary enterprises are those which jointly or interdependently add to the farm income. One crop may add to the income of

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another or a combination may be of mutual aid. Small grains are complementary to legumes by serving as a nurse crop. Legumes are profitable to other crops because of their soil improving qualities. Livestock, in turn, can increase the value of the legumes by furnishing a market for them. Permanent pasture on rough land is a liability to the farmer unless he has some means of marketing it; his livestock will provide a very profitable outlet for this otherwise unmarketable material. Crop residues such as corn-stalks, small grain straws, and cottonseed hulls also can be marketed through livestock.

A farmer might find that tobacco is the most profitable enterprise on his farm, but he might be able to get more gross returns from his farm by leaving tobacco entirely out of his farm organization. A combination of crops and livestock mutually valuable because of their complementary and supplementary relationships will result in a more profitable and a more stable agriculture.

Black lists a fourth relationship, a joint-product relationship, which may add considerably to the choice of farm enterprises. Joint-product enterprises are those which use the same raw products or those which come part of the way at least out of the same production process. The latter is more common on the farm. The skimmilk of a butterfat enterprise might make it profitable to add some hogs to the farm. The wool of a mutton enterprise returns considerable income.

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Governmental Regulations. Economic factors do not always move in a free and independent manner. Men, in his wish to alter conditions for his personal benefits, often resorts to legislative means in an attempt to sway or to counterbalance the natural workings of the principles of production. Tariffs on the importation of products from competing countries largely reserves the domestic market for the home product. The tariff on wool has greatly encouraged sheep production. Other countries interfere with the production of some commodities in the United States because of the restrictions they place upon the importations from this country. The wheat farmers were severely hit by such a move.

Governmental encouragement of reduced production of a commodity by means of bounties or payments for the reduction may alter the enterprises on a farm. Increased idle land might be utilized by livestock. A hog farmer may find that a reduced hog enterprise is unprofitable; he will completely drop hog production and turn his energies elsewhere. This Governmental interference sometimes has only a temporary influence, but often it has a more permanent effect.

Another type of Governmental influence is that related to the land policies of the Federal and State Governments. The opening of the public domain for homesteading made available vast acreages of land for the more extensive systems of farming such as livestock grazing. The relative cheapness and apparently unlimited supply of land led to the more exploitative types of farming. But when the public domain disappears and when economic forces, either independently or with Governmental sanction, begin to point out the follies of such a procedure, a more permanent system of agriculture may be developed. The poorer areas are being returned to pasture lands and to forests. More attention to soil building and conserving practices results in more diversified farms.
More land in legumes and grasses in former one-crop areas will usually be followed by a shift of livestock enterprises to such areas.

Taxation is another Governmental agency influencing agriculture. Some areas are taxed so severely that the farmers must rely upon more intensive enterprises such as truck farming. The more intensive system of farming may really be the primary cause of high taxation; after the high rate is established, however, taxation may be one of the causes retaining the intensive enterprises.
IV. Biological Factors.

The importance of biological factors as forces determining production areas are often overlooked.

Insects, Diseases and Weeds. Diseases, insects and weeds must invariably be considered in the choice of crops and livestock. Some insect pest may completely destroy the enterprises susceptible to its attack. A partial or complete shift of the commodities produced in that area may be necessary; even though the shift may be only until some efficient method of control is discovered, considerable maladjustment, or uncertainty results.

The spread of the Mexican cotton boll weevil northward is an example of the extreme effect an insect may have in causing a change of crops. Elliott states that this pest has done more to force a diversification of crops in the Cotton Belt than any other single factor. It pushed the center of cotton production farther northward.

Hog cholera restricted hog production in some areas until a relatively sure system of vaccination was discovered and put into practice. Contagious abortion has ruined many beef cow herds and is a serious threat to the dairyman. It is almost impossible to clean up a badly infected area unless the dairy or beef enterprises are greatly curtailed. Weeds add to the grief of the farmer. A dairyman who finds his pasture badly infested with wild onions must either change his pasture or kill the weeds. If he can do neither he may have to quit dairying. Dodder seriously interferes with lespedeza production in some areas.

Organic Nature of Living Things. The organic nature of crops and livestock must be considered as a biological factor influencing the production areas of farm commodities. Rotations are necessary to control weeds, insects, and diseases, and to maintain the rate of productivity of the chief cash crop. Clover may be unprofitable but a farmer cannot grow corn continuously without serious losses. A farmer may be able to handle twelve sows quite well, but if he doubles the number he will have more trouble with pig losses per sow even if he increases the labor, equipment, and land in proportion to the number of sows. Farmers of large poultry flocks have much trouble with parasites and disease. This organic nature of living enterprises largely prohibits extreme specialization; a combination is practically dictated if the most profitable business organization is to be employed.

Beneficial Factors. The biological factors are not all of a detrimental nature. Agricultural scientists are continually developing new varieties, strains, and types of crops and livestock. The production areas of various crops has been decidedly extended by the improvement of the drought-resisting capacities of the crops. Cotton production is pushing farther northward because of the development of varieties more suited to cooler weather and shorter seasons. One means of reducing European Corn Borer losses has been the use of supposedly borer resistant strains of corn. Attempts are continuously being made to find higher yielding varieties and strains of crops; such increases may cause a shift of production.

Similar scientific developments are aiding the livestock industries. Dairy cows of higher productivity, more blocky and earlier maturing beef cattle, and more prolific brood sows may change the relative profitability of the enterprises in different areas.
Many of the biological factors are greatly influenced by the climatic and soil conditions. Johnson grass does its greatest damage in warm regions on fertile soils, chinch bugs cannot stand moist, shady conditions, and some of the fungous diseases are more prevalent in the mild, humid regions. Diseases and insects which attack livestock are similarly influenced by physical factors.
V. Social Factors.

Characteristics of the People. The characteristics of the people of a community often play an important part in the choice of the farm enterprises. Areas largely settled by Scandinavians often receive the major part of their income from dairying. Other nationalities of people also have varying specialties, and if conditions permit they will produce the commodities with which they are acquainted. This is a major factor in communities largely settled by one nationality.

The ability and experience of farmers is of sufficient importance to gain attention. Some men cannot get along with livestock; others would hate to depend upon crops for a living. One of the greatest handicaps excluding livestock from many of the southern farms is the low quality of the labor. Even if the individual had the potential ability and temperament required of a livestock man, he would still lack the experience and technical knowledge of livestock farming known by farmers in more diversified regions. Enterprises demanding considerable technique and thriftiness cannot be successfully attempted by shiftless, lazy people. A shiftless negro may make a fair living as a cropper on a cotton plantation, but give him a dairy herd and remove the influence of the plantation owner and he will be completely lost.

Prevailing Community Practices. The prevailing community practices are often quite important. An Angus breeder in a Jersey community will have a severe handicap. His neighbors can exchange herd sires, can organize specialized trade associations, and can be of general aid to each other, but he is severely handicapped by his isolation. The community labor supply is trained along a particular line of farming; the experience of the community is of utmost value to every farmer of the
neighborhood; the advertising value of a specialized community results in greater profit.

A prevailing community type of farming is very hard to change. Warren says that the wrong enterprise may continue for years, because the farm buildings, the city warehouses, the marketing agencies and the knowledge or training of the people must be changed before the more desirable enterprise can be profitably adopted.

Quite often, however, a farmer may find it profitable to produce a product not grown in his community. There is a local demand that needs to be supplied. A livestock farmer in a strictly crop producing area may be able to profitably dispose of his surplus meat to his neighbors.

**Personal Choice.** The final decision of the commodities to produce is up to the individual. His personal likes or dislikes will act as a unifying agent or a guiding hand in his more or less unconscious summary of the prevailing factors limiting or encouraging the production of various commodities. Quite often the apparent advantages of competing enterprises are so nearly balanced that he must fall back upon his personal choice as a deciding issue. Many hog farmers could sell their corn with equal or possibly greater net profit, but they raise hogs because they like to be around livestock.

Quite often you hear a farmer say that he literally hates to milk cows, but that he is willing to because of the additional profit they make for him. His personal choice is to make money and he is willing to throttle his dislikes accordingly. Some people are willing to disregard their personal inclinations; others disregard the existing advantages and disadvantages in response to their own wishes.

VI. Summary.

The commodities produced in an area are the results of the individual and collective efforts of men to utilize the economic and productive resources available to them. Each farmer attempts to adjust his production activities so as to utilize the available resources to the best of his knowledge and to his own satisfaction.

The producer ordinarily will not produce a large number of commodities. He tends to use his resources for the production of goods of which the costs are comparatively lowest in excess of his own consumption, and he will buy with his returns those products of other producers to satisfy his wants.

Black summarizes the localization of production in two general laws. The first is the Principle of Specialization:

Each area tends to produce only a few things—frequently only one—and to sell its surplus of these, and with the proceeds buy the other things needed.

The second presents the real problem of determining what an area will produce. It is:

Each area tends to produce those products for which its ratio of advantage is greatest as compared with other areas, or its ratio of disadvantage is least, up to the point where the land may be needed by some products less advantaged in the area in order to meet the demand for them at such prices as will come to prevail under such circumstances.

Quite often all of the potential advantages of an area are not recognized, but as competition forces farmers to abandon old enterprises and as more alluring enterprises appear, a community will produce those commodities more greatly favored by the existing conditions.

VII. List of Commodities to be Considered.

The agricultural commodities which are or may be of economic importance on Tennessee farms may be classed in eleven different groups by considering both their biological classification and their use. The list is not complete; the group of ornamental plants could be enlarged considerably if it is wished to do so.

Some of the products are useless, perhaps a pest, at the present time. This situation may change making it well worth while to produce some of these practically unknown commodities.

Neither time nor space permits a comprehensive study of all the listed commodities. Only the more important ones will be considered.

I. Cereal Grains.

<table>
<thead>
<tr>
<th>No.</th>
<th>Commodity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Barley. *</td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Spring. *</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Winter. *</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Buckwheat. *</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Corn. *</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Emmer.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Oats. *</td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Spring. *</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Winter. *</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Rice. *</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Rye. *</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Grain Sorghums. *</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Wheat. *</td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Hard red winter. *</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Hard red spring. *</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>Soft red winter. *</td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>Club.</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>Poulard.</td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td>Durum. *</td>
<td></td>
</tr>
</tbody>
</table>

* Commodities Considered.
### II. Legume Crops.

1. Alfalfa.
2. Velvet bean.
3. Alsike clover.
6. Crimson clover.
7. Egyptian clover.
8. Mammoth clover.
9. Mexican clover.
10. Red clover.
11. Sweet clover.
12. White clover.
13. Cowpea.
15. Lespedezas.
   a. Common.
   b. Korean.
   c. Sorisena.
17. Soybean.
18. Vetch.
19. Field Pea.

### III. Non Legume Forage Crops.

1. Kentucky bluegrass.
2. Canada bluegrass.
3. Bermuda grass.
4. Brass grass.
5. Johnson grass.
6. Carpet grass.
7. Rescue grass.
8. Reed Canary grass.
9. Orchard grass.
10. Sudan grass.
11. Wild, salt, and prairie grasses.
12. Perennial ryegrass.
13. Italian ryegrass.
15. Meadow fescue.
17. Rape.
18. Redtop.
19. Forage Sorghums.
20. Timothy.

* Commodities Considered.
IV. Other Field Crops.

1. Broom corn. *
2. Cotton. *
3. Flax. *
4. Hemp.
5. Mangels-Wurzel.
6. Irish Potato. *
7. Sugar Beet. *
8. Sugar Cane. *
10. Sweetpotato. *
11. Tobacco. *
   a. Dark fire cured. *
   b. Dark air cured. *
   c. Bright flue cured. *
   d. Wrapper cigar leaf. *
   e. Binder cigar leaf. *
   f. Filler cigar leaf. *
   g. White burley. *

V. Livestock.

1. Beef cattle. *
   a. Feeder.
   b. Stooker.
   c. Beef cow herd.
   d. Purebred breeding herd.
2. Honey bee.
3. Chickens. *
4. Dairy cattle. *
   a. Whole milk and butter.
   b. Cash cream.
   c. Manufactured products.
5. Ducks.
7. Goats. *
8. Guinea.
9. Hogs. *
10. Horses. *
11. Mules. *
12. Sheep. *
14. Turkey.

* Commodities Considered.
VI. Truck and Vegetables.

1. Artichoke.
2. Asparagus.
3. Beans, 
   a. Field.
   b. Kidney.
   c. Lima.
   d. Snap or string.
5. Broccoli.
7. Cabbage.
8. Cantaloupes.
9. Carrots.
10. Cassava.
11. Cauliflower.
12. Celeriac.
13. Celery.
15. Collards.
16. Sweet Corn.
17. Cress, garden, upland.
18. Cucumbers.
20. Endive.
22. Greens, except spinach.
23. Horse radish.
24. Kale or borecole.
25. Kohlrabi.
26. Leeks.
27. Lentil.
28. Lettuce.
29. Musk melon.
30. Mustard.
31. Okra.
32. Onions.
   a. dry.
   b. green.
33. Parsley.
34. Parsnips.
35. Pear.
   a. green.
   b. ripe field.
36. Pepper.
37. Pomegranate.
38. Pop corn.
39. Pumpkin.
40. Radish.
41. Rhubarb.
42. Romaine or Cos lettuce.
43. Rutabaga.
44. Salsify.
45. Shallots.
46. Spinach.
47. Squash.
48. Swiss chard.

VII. Fruits and Nuts.

1. Almond.
2. Apple.
3. Crab apple.
4. Apricot.
5. Blackberry.
8. Cherry.
9. Cranberry.
11. Dewberry.
12. Elderberry.
15. Hickory.
17. Juniper berry.
18. Logan berry.
20. Mulberry.
22. Chestnut.
23. Oak nut.
25. Peach.
27. Pear.
28. Persimmon.
29. Plum.
30. Quince.
31. Pecan.
32. Raspberry.
33. Strawberry.
34. Black walnut.
35. California walnut.
37. Persian walnut.
VIII. Ornamental Plants.

1. Barberry.
2. Holly.
5. Peony.
6. Rose.
7. Lily.
8. Tulip.

IX. Forest Products.

1. Chinkapin.
2. Maple sugar and sirup.
3. Mistletoe.
5. Sassafras.

X. Game and Fur.

1. Bear.
2. Deer.
3. Fish.
4. Fox, red, gray, silver, black.
5. Frog.
7. Grouse.
8. Mink.
10. Opossum.
11. Otter.
13. Quail.
15. Racoon.
17. Turtle.
18. Weasel.
19. Wild cat.
XI. Miscellaneous.

1. Arrow root.
2. Beggar weed.
3. Scotch broom.
4. Buffalo berry.
5. Burnet.
6. Castor bean.
7. Chufus.
8. Corn salad.
10. Dyes and Dye stuffs.
11. Escarole.
15. Hops.
17. Lupine.
18. Medicinal crops.
19. Medlar.
20. Milk wood.
22. Mushrooms.
24. Silk worm.
25. Raffia.
26. Upland taro.
27. Teasel.
28. Wintergreen.
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CHAPTER II.

CEREAL CROPS.

I. Corn.

Corn is the most important single crop grown in the United States, exceeding in production and value wheat, oats, barley, rye, rice and buckwheat combined. Enough corn to be of some importance is produced in every State of the nation. It is, evidently, quite cosmopolitan in its choice of growing conditions. Carrier makes the following statement concerning the widespread nature of its production:

The Indians had developed types of corn suitable to the various soil and climatic conditions of America, such as the flint for the North, the prolific for the South and the dents for the Corn belt, which the white farmers have not been able greatly to improve.

Maine and Nevada, according to Figure I, are the only states with less than 10,000 acres of corn in 1929. Iowa, Illinois, Kansas and Nebraska show the greatest concentration of corn acreage. Three broad limiting factors stand out at once; the western limit is set by rainfall, the northern limit is set by the length of the growing season, and the southern limit of the extremely heavy area is set by soil differences.

Climatic Factors. Rainfall and temperature and length of growing season are the most important climatic factors influencing the corn production areas. A line drawn where the mean summer rainfall falls below eight inches pretty generally marks the western boundary of heavy corn production. There is very little corn grown where the mean summer temperature falls below 66 degrees or where the mean night temperature for the same period falls below 55 degrees. Varieties of corn maturing in ninety days are grown near the northern edge of the corn producing area, but some varieties grown in the South require as much as 180 days from planting to maturity. Most of the corn produced for grain is grown where the growing season is at least 140 days. 3

Figure 1 shows that the dry states of western United States produce very little corn. The profound influence of rainfall upon corn producing areas can be further demonstrated by showing the correlation between yields and rainfall.

It is reasonable to expect that any factor which affects yields will also have something to do with the location of production areas.

Rainfall. Smith states that in places where the temperature and the sunshine are generally sufficient the development of the plant and more especially the crop yield depends most largely upon the rainfall; this is particularly true in the drier part of the United States west of the Corn Belt and is true to a large extent in the Central and Eastern part of the country. Rainfall, therefore, must be the primary controlling weather factor in the location of corn regions. Smith is of the opinion that the rainfall from about the middle of July to the middle of August has a far greater effect upon the amount of corn produced than that for any other period of similar length. A combination of low rainfall and high temperature during the ten days following tasseling has a very unfavorable effect upon the yield. Table I shows the correlation between rainfall for different periods and corn yield.

Table I.
CORRELATION OF RAINFALL AND THE YIELDS OF CORN FOR INDIANA, ILLINOIS, IOWA AND MISSOURI, 1888 - 1911.

<table>
<thead>
<tr>
<th>Correlation of Rainfall for</th>
<th>Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>June and Corn Yield</td>
<td>+ .34</td>
</tr>
<tr>
<td>July and Corn Yield</td>
<td>+ .73</td>
</tr>
<tr>
<td>August and Corn Yield</td>
<td>+ .48</td>
</tr>
<tr>
<td>June and July and Corn Yield</td>
<td>+ .68</td>
</tr>
<tr>
<td>July and Aug. and Corn Yield</td>
<td>+ .63</td>
</tr>
<tr>
<td>June, July and Aug. and Corn Yield</td>
<td>+ .69</td>
</tr>
</tbody>
</table>


Such a correlation is only an approximation because other factors which may be present are not held constant. They might be grouped in such a manner as to either increase or decrease the correlation coefficient as worked out. Besides this, the area is not homogenous in either of the two variables being used. Small areas within the four states not producing corn may have the most variable or the least variable rainfall resulting in an abnormal balancing of the remainder of the area. Some significance, however, must exist in the relatively high figure of + .73 for July as compared to the lower correlations found for June and August.

Computed correlations between mean daily temperature at different periods of growth of the corn plant and corn yields show little or no relationship. Corn growth is retarded by cool weather or cold nights, but the importance of moisture is much greater. The corn plant requires its greatest moisture in the summer when the high temperatures are causing great evaporation and when droughts are liable to occur.5

Figure 2 shows the relationship between corn yields and July rainfall in Tennessee from 1898 to 1934. With the exception of 1902 and 1926 the two lines run fairly well together. (There are other exceptions but these are outstanding.) Note that both years are the second year of a comparatively low rainfall. The sudden rise in yield might be the result of an accumulation of available nitrogen in the soil. Only a limited amount of nitrogen becomes available for plant use each year and if it is neither used by the crop nor leached out by rainfall there will be an increased amount available the next year.

Figure 2. Relation between the July rainfall and the yield of corn in Tennessee 1898-1934

Source: Table II.
Table II.

THE JULY RAINFALL AND THE YIELD OF CORN IN TENNESSEE, 1898 - 1934.

<table>
<thead>
<tr>
<th>Year</th>
<th>July Precipitation</th>
<th>Yield of Corn</th>
<th>Year</th>
<th>July Precipitation</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1898</td>
<td>5.92</td>
<td>26.0</td>
<td>1918</td>
<td>3.57</td>
<td>24.0</td>
</tr>
<tr>
<td>1899</td>
<td>4.53</td>
<td>20.0</td>
<td>1919</td>
<td>2.62</td>
<td>21.4</td>
</tr>
<tr>
<td>1900</td>
<td>4.14</td>
<td>20.0</td>
<td>1920</td>
<td>3.33</td>
<td>28.0</td>
</tr>
<tr>
<td>1901</td>
<td>2.01</td>
<td>14.2</td>
<td>1921</td>
<td>4.73</td>
<td>25.9</td>
</tr>
<tr>
<td>1902</td>
<td>1.97</td>
<td>21.9</td>
<td>1922</td>
<td>5.55</td>
<td>23.0</td>
</tr>
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<td>1903</td>
<td>3.80</td>
<td>23.5</td>
<td>1923</td>
<td>3.99</td>
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<td>1904</td>
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<td>25.0</td>
<td>1924</td>
<td>3.81</td>
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<td>1905</td>
<td>4.32</td>
<td>24.6</td>
<td>1925</td>
<td>3.34</td>
<td>20.0</td>
</tr>
<tr>
<td>1906</td>
<td>6.90</td>
<td>28.1</td>
<td>1926</td>
<td>3.36</td>
<td>27.5</td>
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<td>1907</td>
<td>4.05</td>
<td>26.0</td>
<td>1927</td>
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<td>1908</td>
<td>3.85</td>
<td>24.3</td>
<td>1928</td>
<td>3.57</td>
<td>19.5</td>
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<tr>
<td>1909</td>
<td>4.57</td>
<td>22.0</td>
<td>1929</td>
<td>4.42</td>
<td>22.7</td>
</tr>
<tr>
<td>1910</td>
<td>6.53</td>
<td>25.9</td>
<td>1930</td>
<td>2.33</td>
<td>14.0</td>
</tr>
<tr>
<td>1911</td>
<td>4.76</td>
<td>26.8</td>
<td>1931</td>
<td>4.32</td>
<td>25.0</td>
</tr>
<tr>
<td>1912</td>
<td>5.80</td>
<td>26.5</td>
<td>1932</td>
<td>4.76</td>
<td>20.3</td>
</tr>
<tr>
<td>1913</td>
<td>3.45</td>
<td>20.5</td>
<td>1933</td>
<td>6.01</td>
<td>23.5</td>
</tr>
<tr>
<td>1914</td>
<td>4.30</td>
<td>24.0</td>
<td>1934</td>
<td>4.42</td>
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</tr>
<tr>
<td>1915</td>
<td>4.38</td>
<td>27.0</td>
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<tr>
<td>1916</td>
<td>7.30</td>
<td>26.0</td>
<td></td>
<td></td>
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<tr>
<td>1917</td>
<td>6.79</td>
<td>29.0</td>
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</table>


Care must be used in interpreting the results of such a chart because of the failure to hold constant the variables not being measured and because of the lack of homogeneity in the area concerned. If the variations in rainfall in regions where it is generally plentiful have such effects upon production, there is no doubt that the dry regions are unfavorable corn areas.
Soil. Richey\textsuperscript{6} states that other things being equal, corn grows best on fertile, well-drained, loamy soils that are neither too light nor too heavy. The Corn Belt is the result of the abundance of prairie soils combined with an adequate supply of moisture. Well drained bottom or second-bottom land, if not too sandy, and the loess soils near the Mississippi River are also excellent corn lands.

Morgan\textsuperscript{7} lists the following soils, common in the Cotton Belt, as very poor for corn production:

1. Sandy soils deficient in organic matter and mineral plant food.
2. Uplands from which the greater part of the top soil has been lost by erosion.
3. Rich bottom lands which, for lack of drainage have become cold and sour.
4. Very stiff and compact clays through which the roots cannot penetrate, and which, because of their physical character, are very hard to prepare.

Soils of low water-holding capacity, such as sands, are quite unsatisfactory where the rainfall is low. Heavy, poorly drained soils result in a waterlogged condition, and when this condition exists the nitrifying processes are hindered.\textsuperscript{8} Good drainage is necessary.

Another soil factor that limits corn production is the matter of erosion in the regions of rolling lands and large rainfall. In such localities the fertility of the surface soil soon becomes depleted, because the combination of the two factors mentioned seriously increase erosion.\textsuperscript{9}

The soluble plant food elements and the finely decomposed and disintegrated soil particles, which are necessary for successful plant growth, are the first parts to be washed away leaving a raw, partially formed soil unfit

\textsuperscript{6} Richey, F. D., \textit{op. cit.}, p. 6.
\textsuperscript{7} Morgan, J. O., \textit{Field Crops for the Cotton Belt}, p. 212.
\textsuperscript{8} Montgomery, E. G., \textit{The Corn Crops}, p. 70.
\textsuperscript{9} Ibid, p. 70.
for agriculture behind. To make matters worse a corn crop offers little or no protection against erosion.

Richey\textsuperscript{10} summarizes the necessity of a good soil in the following quotation:

Corn is a rich-land crop. It must make a considerable plant growth before any grain is formed. On poor soils vegetative growth may use most of the available nutrients, leaving little for the production of grain during the latter part of the season. Hay or pasture crops are better suited to poor soils. In these crops the entire plant is of value, and yields will be about in proportion to the productivity of the soil and season. In corn, on the other hand, a fair growth of stalk with a low yield of grain profits little. To attempt corn growing on unproductive soils is to invite low yields and these, with the necessary high cost of production, can mean only losses.

Poor lands, therefore, must revert sooner or later to hay and pasture crops if it has been used for corn, or if such lands are not now being used for corn there is little reason to expect them to be so used for any period of time.

\textbf{Topography.} Corn is a crop that is well adapted to extensive farming systems. Large, level, regularly shaped fields make possible the use of big power units and machinery with a resulting lowering of unit costs of production. Level topography, therefore, adds much to making a region favorable for economical corn production.

Besides the economy of operations resulting from the level topography, there is another relationship arising that does much to make such areas more ideal for corn production. Level lands result largely from glaciation and glaciated soils are normally quite fertile; level lands are often prairie lands and prairie soils are usually black or brown as compared to

\textsuperscript{10} Richey, F. D., \textit{op. cit.}, p. 3.
the yellow or grey timber soils; level lands wash less with a correspond-
ing less loss of fertility. A level topography adds much to a corn region.

**Economic Factors.** Economic factors have considerable influence upon
the production areas of corn. It is a relatively heavy product per unit
of value; consequently it must be consumed close to where it is produced
unless waterway shipments are possible. Figure 3 shows the uses of corn
harvested for grain. Hogs are fed 40%, livestock receives more than 35%,
and somewhat less than 10% is used directly for food.

The small usage of the crop for human food means that there will
be no necessity of the crop being located near large centers of popula-
tion. The amount consumed by horses and mules (probably much less now
than in 1921 because of the decrease in the number of horses) is practic-
ally a farm consumption matter. Meat producing animals have a per unit
weight value high enough to permit their shipment long distances; fat
cattle and hogs offer a farm market for corn in the surplus regions.

Much of the corn, therefore, can be produced where the conditions are
most ideal.

Production of more perishable human foods of animal origin which can-
not be shipped long distances presents a condition whereby some corn is
desirable near the population centers. Dairymen generally locate them-
selves near the cities, and, whether they raise their own corn or buy it,
this part of the corn acreage tends to locate itself near the cities.

Another related factor is that corn for silage requires less ideal
climatic and soil conditions than that produced for grain because of the
use of the total plant. The growth of silage corn in Wisconsin and
New York north of the point where a grain crop will mature is an example
of this situation.

It can be expected that the corn in the surplus corn areas nearest
Figure 3. The uses of corn harvested for grain in the United States, based on estimates by the U.S. Department of Agriculture.

Source: Leighty, C.E., Warburton, C.W., Stine, C.C. and Baker O.E.

"The Corn Crop" U.S.D.A. Yearbook of Agriculture 1921, p.165
the cities (type of transportation considered) will be sold on the cash market while that farther away will go to beef cattle and hogs. Iowa and Nebraska farmers feed their corn, while those of East Central Illinois and Indiana sell theirs not only because the population concentration of Chicago is nearby but because the Chicago marketing machinery affords an economical gateway to the East via the Great Lakes. This condition is not so important in locating corn producing areas as it is in the dictatory influence of corn upon the choice of other farm enterprises such as the choice of livestock and the choice of crops supplementing corn and the livestock.

Part of the Cotton Belt could grow corn quite economically so far as soil and climate are concerned, but cotton is grown because the crop with the smallest potential available acreage of suitable conditions has first choice to the land. This same factor is present with other competing crops such as tobacco, potatoes and truck crops.

Corn is also a crop that tends to fit in where conditions are not generally favorable for it but where the conditions are much less favorable to other crops. This is because of the widely variable conditions under which corn can be produced and because of its great feeding value. Henry and Morrison state that no other cereal yields, on a given space and with a given expenditure of labor, so much animal food in both grain and forage.

Several economic factors within the organization of the farm greatly influence the percentage of the crop acres in corn. Supplementary, complementary and competing relationships in regard to the use of land, machinery and labor must be given some consideration by the farmer if he is to fully utilize his resources. Such factors do not definitely ex-

clude corn production, but they work to bring about combinations of corn with other crops with a resultant decreased acreage of corn.

**Biological Factors.** Certain biological factors are present which, although they do not often completely exclude production, greatly reduce the amount of corn raised. Chinch bugs, corn-ear worms, army worms, grasshoppers and European Corn Borers all injure corn in varying amounts from year to year. Sometimes the infestation may become so heavy that corn production will have to be temporarily abandoned or at least limited to the minimum. Chinch bug infestation is greater during years of drought.\(^\text{12}\) Most damage by the European Corn Borer has been in the Northeastern States.

Corn diseases such as common smut and the root, stalk and ear rots are quite destructive. The heaviest losses from smut are in the semi-arid regions of the Great Plains where the disease seems to be increasing in its destructiveness. The rots are more prevalent in regions where the soil is deficient in calcium and phosphorus.\(^\text{13}\)

**Social Factors.** Some farmers may be producing corn because their fathers did or because other farmers in the community do. They know how to grow corn and may know nothing of the cultural practices of a potentially competing crop. Perhaps they are equipped for corn and can afford to raise it in place of a more profitable crop because of the expense of changes.

**Regional Cost of Production.** Figure 4 shows the differences in cost of production of corn in different areas. Note that materials and labor are much greater in the states where the corn is shocked than it is in

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\(^\text{12}\) Leighty, C. E., et. al., *op. cit.*, p. 186.
<table>
<thead>
<tr>
<th>State</th>
<th>Yield</th>
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<tr>
<td></td>
<td></td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>% Husked from Standing Stalks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indiana</td>
<td>50</td>
<td>[ ]</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>% Husked from Shocks</td>
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</tr>
<tr>
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<tr>
<td>Average</td>
<td>55</td>
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</table>

Figure 4. Regional variations in the cost of producing corn

the others. Even after subtracting the credits for fodder, the costs in
the midwest are lower per acre than those in the Eastern States.

II. Wheat.

Wheat is one of the most important crops in the United States. The
distribution throughout the country is practically as wide as that for
corn. Figure 5 shows the distribution in the four principal wheat
regions.

Physical Factors. The physical conditions which affect the pro-
duction of wheat, according to Baker, may be classified into four
groups:

1. Temperature conditions, particularly growing season
   temperatures and dates of occurrence of spring and
   fall frosts.
2. Moisture conditions; that is rainfall, snowfall, hail,
   fog, humidity, rate of evaporation.
3. Topography or land form; that is, the configuration of
   the earth's surface, degree and direction of slope,
   roughness or smoothness of the land.
4. Soils, including both physical structure and chemical
   and bacteriological characteristics.

In general, climatic similarity characterizes much broader
areas and the transition from one type of climate to another is
less abrupt than in the case with the types of soil and land
surface. Temperature conditions are peculiarly pervasive and
practically unalterable. They set the outer limits to crop
production. Whether a crop is grown within these temperature
limits depends upon the moisture, the topography and the soils,
and also upon the economic situation.

Climatic Adaptations. The lowest mean temperature for the three
warmest months (usually June, July and August in the northern hemi-
sphere) at which wheat production is possible is approximately 57 de-
grees. There should be no severe frosts during the latter two months

Vol. I, No. 1; March, 1925; p. 21.
of the period. Barley and potatoes are the only crops grown under colder condition.15

The minimum soil temperature for the growth of wheat is 41 degrees, the maximum is 108.6 degrees and the optimum is 85.6 degrees.16 This range is wide enough to permit quite a wide choice of regions so far as temperature is concerned. Morgan17 states that the best quality together with the highest yields of wheat are possible only in regions of cold winters, followed by long, cool, moderately wet spring seasons and dry sunny weather during ripening.

Wheat may be grown in the hottest parts of the earth if the climate is not humid. (See p. 49) The humidity of the tropics is largely responsible for the restriction of the major wheat regions to the temperate zones. A moist climate, whether it be cool or warm causes the rusts, smuts and other diseases of wheat to flourish. It is true that the upper limit of humidity largely depends upon the temperature. Very little wheat is grown in regions where the average temperature for the two months preceding harvest exceeds 68 degrees, such as Southeastern United States, if the annual rainfall exceeds 50 inches. Farther north where the temperature is a few degrees cooler very little wheat is raised where the annual rainfall exceeds 40 inches.18 The largest yields of the best quality grain result from a cool spring and a condition of high moisture content in the soil during the early stages of growth. The latter condition is conducive to tillering.19

15. Ibid, p. 22.
A corresponding situation exists with the arid limit of wheat production and temperature. It appears as if the minimum annual rainfall for the cold limits is about 10 inches and that for the hotter regions is 20 inches. In the driest regions it is a common practice to conserve the moisture of one season by summer fallowing so that much of the rainfall for two seasons is combined for the crop the second year. Annual rainfalls of 10 and 40 inches are the minimum and maximum limits for the coldest regions, and those of the hottest regions are 20 and 70 inches.

Soil. Fertile well-drained loams, silt loams, clay loams and clays, amply supplied with humus and underlain with a heavy but well-drained subsoil, are the best soils for wheat production. The water holding capacity for such soils is very high. Another essential, on the other hand, is good drainage, because a water-logged soil is frequently a serious factor against obtaining a full stand of wheat. Heavy, poorly-drained soils with impervious subsoils cause severe injury or complete killing by the standing water during the growing season or by smothering from ice during the winter. Alternate freezing and thawing on low, poorly drained soils causes considerable heaving.

Sands, sandy loams and other light textured soils may produce good wheat crops when the rainfall is favorable, but the chances of low yields are much greater; such soils have a limited water holding capacity and dry out very quick in dry years, thus causing the crop to suffer more than it would on a heavier soil. If the subsoil also should be open, the light soils are even more unsatisfactory, for the return of moisture to the surface by means of capillary action is retarded. Soils coarser than loams

in texture are better adapted to the cultivated crops and long rooted legumes. Rye and oats of the small cereal grains do better than wheat on poor soils. A soil nearly neutral in acidity reaction is preferable for wheat culture, yet the crop will tolerate a mild degree of acidity. 22

Topography. Baker states that the topographic limits of wheat production are less definite and more localized than the climatic limits. Land too rough, steep, or hilly for the economical employment of large power and machinery units is not favorable for wheat production. Very little wheat is grown on land steeper than slopes of 15 feet fall per 100 feet horizontal distance in the temperate regions. Steep hillsides in the tropical regions can be used because these rapidly, eroding soils are un-leached and fertile.

Economic Factors. Six economic and social principles, according to Baker, 24 are important in determining what proportion of the land physically adapted to wheat will be used for its production.

The first choice of the land, if the demand be sufficient, will go to the crop or other agricultural product which is most limited in its physical requirements. Wheat is excluded from the Corn Belt and the Cotton Belt because these two crops have a narrower range of economical production. They have a sort of a natural monopoly which demands a price sufficiently high to give them an advantage over wheat.

The second principle has to deal with the bulkiness of the product and its influence upon transportation costs. The cost of transportation can be best carried by a product which has a small weight per unit of value. It will demand those regions best physically fitted for its production while a commodity with a great bulk will locate itself more nearly to the center of

22. Ibid., pp. 168-169.
24. Ibid., pp. 31-35.
consumption with less regards for the physical adaptability of the region. Wheat cannot be shipped as far as cotton, but its value is normally much greater than that of corn. Furthermore in regions such as the Cotton Belt where corn is needed for feed and wheat for human food, the corn will be grown locally because of its greater bulk and the wheat will be imported from more distant regions.

Internal relationships such as the complementary and supplementary nature of the products make up Baker's third principle. The tendency to diversify the agriculture of a region is caused by the varying seasonal requirements for labor, power and equipment. If the farmer can plant and harvest a crop of wheat at a time when his labor and horses otherwise would be idle, he can lower the production costs on his major enterprise sufficiently to justify the inclusion of wheat in his rotation.

Closely connected to the third factor is the desirability to grow a combination of crops which will maintain soil fertility and promote freedom from insects and disease. The standard skeleton rotation consists of an intertilled crop, a small grain, and a legume or grass crop. Wheat is produced in many regions where it would be excluded otherwise because of the essential part of a small grain in a well balanced rotation. It may have a somewhat different soil fertility requirement than the main crop, it tends to reduce erosion, and it makes a good nurse crop.

It is the natural tendency to produce the most productive crops on the most valuable land. As population increases and land becomes more scarce relatively, a greater proportion of the land area will be devoted to the most productive crops. Wheat occupies a sort of central position; it is excluded by corn, cotton and truck or orchard crops and in turn it tends to push oats, rye and the cheaper hays back to the poorer soils.
Factor number six is of a somewhat more social nature. It has to deal with the character of the farm population and the accumulated community skill and experience. The inertia of ignorance causes wheat to be excluded from many regions where it could be grown quite well and causes it to be grown in regions long after new conditions have developed which would make a different agricultural system more profitable. This factor normally decreases in importance and the other five have an increased influence as education becomes more widespread and farmers become more responsive to economic stimulus.

Regional Differences by Types. Different kinds of wheat are produced in different parts of the country. Smith states that in general a hot, dry climate produces a fine-stemmed plant the grain of which is hard, glassy and rich in protein, while soft and mealy grains that are poor in nitrogen result from a cool moist climate. Another difference comes from the fact that certain regions can only produce spring types, while others can better produce winter types, and still others are fit for either.

United States can be divided into four principal wheat regions as is shown by Figure 5; they are the western region (mostly white wheats), the hard red winter wheat, the hard red spring wheat and the soft red winter wheat.

**Hard Red Winter Wheat.** Hard red winter wheat is best adapted to regions where the annual rainfall is less than 35 inches such as portions of Kansas, Nebraska, Oklahoma and Colorado; there is very little competition with other classes of wheat in this region. Figure 6 shows the distribution of Hard Red Winter Wheat in the United States in 1929. Soft

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Figure 5. Distribution of wheat in the United States in 1929. The heavy black lines show the approximate boundaries of the four principal wheat regions.

Figure 6. Distribution of hard red winter wheat in the United States in 1919. Estimated area 21,677,900 acres.
red winter wheats offer more competition as the rainfall increases, and in such regions as eastern Kansas and Oklahoma, northern Missouri, southern Iowa and central Illinois, where the annual rainfall varies between 35 and 40 inches, the hard red winter wheats are adapted only to the higher and drier soils that are less fertile. In western United States where the annual rainfall is around 15 inches (such as the drier sections of Oregon, Washington and Idaho) hard red winter wheat is well adapted and successfully competes with the other varieties grown in this region. The hard winter wheats are the only winter varieties which will survive the extreme winter temperatures of southern Minnesota, South Dakota, Wyoming and Montana. Here, however, spring wheats are produced in greater quantities.\(^26\)

Salmon\(^27\) makes the following statement in regard to the division line between the production areas of winter and spring wheats:

The isotherm of 10 degrees daily minimum temperature coincides remarkably well with the northern boundary of winter wheat culture and the southern for spring wheat if this boundary is taken as the line beyond which spring wheat is grown more commonly than winter wheat. Some spring wheat is grown south of it, but very little winter wheat is grown north of it.

In other words, spring wheat can be grown wherever winter wheat is a success, but winter wheat has a much quicker northern boundary. Many exclusive wheat farmers in regions where both can be grown find that they can care for a greater acreage of wheat if they grow both. By so doing they can more fully utilize the available power and labor.


Spring wheat fits into a rotation where corn is the principal crop because of the difficulty in getting a stand of corn after winter wheat. Some regions where the fall rainfall is insufficient to insure germination before winter often prevents the production of winter wheat in favor of the spring varieties.  

Another factor causing extreme damage to winter wheat unless the date of seeding is not postponed beyond the fly-free date is the Hessian fly. In areas where spring wheat can be successfully grown the fly may be quite instrumental in forcing the abandonment of winter wheat. Still another factor is the chinch bug in the major part of the Corn Belt. Very strong prejudices are held against winter wheat because it harbors the insect. The feeling is often so strong that farmers who attempt to raise winter wheat will be severely boycotted.

**Hard Red Spring Wheat.** Hard red spring wheats, according to Figure 7, are best adapted to the colder regions of the United States where the winters are too cold for the production of winter wheat. Winter wheat, partly because of the earlier maturity which enables it to partially escape the hot weather, drought, and diseases and partly because of the longer growing period, is usually more productive than spring wheat wherever the winters are not too severe. Spring wheat, therefore, either must supplement winter wheat production or fill in where the latter cannot be grown. The growing of both affords a better distribution of labor and power and lessens the seasonal risk in the regions where both can be successfully grown. Spring wheat also acts as an emergency crop where the fall-sown crop has winterkilled. No hard red spring wheat is grown successfully in regions warmer than the Corn Belt.

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28. Ibid., p. 22.
The durum wheats yield somewhat more than the hard red spring wheats in the eastern part of North Dakota and South Dakota and in the northern Great Plains area because the latter varieties are more susceptible to drought and to stem rust; yet in favorable years the hard red spring wheats yield practically as well as the durum varieties. Higher prices quite often prevail for the hard red spring wheats because of the greater domestic demand thus making the net returns per acre from these varieties greater than that from the durum wheats. The relative market price of each has much to do with determining which will be grown.  

30. Ibid, p. 5.
immediately east of the above mentioned area is because of its resistance
to stem rust, but they often develop a soft, starchy kernel and therefore
are not well adapted although they usually outyield common spring wheat. 31

There usually has been an active foreign demand for durum wheats, but
the domestic market has not kept pace with production because the mills
were not equipped satisfactorily for grinding them and there was little
demand for the product. Market prices depend largely upon the export de-
mand. If this demand slackens, the price of durum wheat in the United
States falls considerably below that of hard red winter wheat. If it were
not for the superior grades and higher yields which often result because
of its greater resistance to drought and rust, durum wheat would not be so
important. 32

Soft Red Winter Wheat. Another of the classes of wheat officially
recognised in the United States is the soft red winter wheat grown
almost exclusively from fall seedings. This class contains most of the
wheats grown in the eastern half of the United States where the climate
is humid. Soft red winter wheats are best adapted to humid regions where
the winters are moderate; the hard red winter wheats will withstand much
more severe winters. The effects of excessive moisture, however, are
withstood better by the soft varieties. They have a stiff straw that is
not especially subject to lodging and so develop normally in wet years.
The soft red winter wheats are generally not resistant to rusts and mildew
to any marked extent. In general they are grown in those sections of
eastern United States where the annual rainfall is over 30 inches and
where the winters are not too severe. North New England and the upper

32. Ibid, pp. 3 - 4.
Great Lake Region are normally too cold.\textsuperscript{35}

In the areas where the production of the two winter classes of wheat overlap, the acreage of each fluctuates considerably because of the seasonal weather conditions and price relationships. In the dry seasons the hard red winter wheats usually outyield the others and vice versa, and in seasons of extreme cold winters the hard varieties do better. The relative market price shifts from season to season thus affecting the acreage of each. Quite often the low heavy soils are used for the soft red winter wheats while the higher, lighter and drier soils go to the production of hard varieties. Commercial bakers prefer the flour from hard wheats, but the soft varieties have considerable demand for pastries and home baking.\textsuperscript{34}


\textsuperscript{34} \textit{Ibid}, p. 5.
III. Oats.

The third most important grain crop in acreage and farm value in the United States is oats. Figure 8 shows that the principal oat producing region in the United States is that north of the Ohio River and between New York and the Dakotas.

Figure 8. Distribution of the oat acreage in the United States according to the census of 1919.

General Adaptations. Oats are not so important as a money crop in the above outlined region as are corn and wheat; yet they have maintained a place in the Corn Belt because of their value as a feed grain, because they fit into the rotation very well from both a labor and a fertility standpoint and because of their use as a transitory crop between corn and legume or grass crops. It is true that the disappearance of the horse has caused a decrease in that part of the oats market, but this is partially substituted by the increased use of oats for young stock.
and dairy cattle.

**Climate.** Cool, moist regions such as Northern United States are best adapted to oats. A distinct type, the Red Rustproof and its relatives, is better adapted to the hotter regions than is the common species of Avena sativa. Although the great oat-producing areas are found mostly in the more humid regions, the seasonal distribution of rainfall is more of a limiting factor than total rainfall. If hot, dry weather occurs during the ripening period, reduced production is inevitable. Winter-killing is a problem in only those regions where the crop is fall sown. A considerable acreage of red oats is grown in the dry, hot region immediately west of the Mississippi River. See Figure 9.

![Figure 9. The distribution of Red Rustproof oats in the United States in 1919. Since 1919 a considerable portion of this acreage has been occupied by Fulghum and Kanota. Source: Stanton, T. R. and Coffman, F. A., Spring-Sown Red Oats, U. S. D. A. Farmers' Bulletin No. 1583, p. 17.](image)

Soil. Stanton states that the rich prairie loams as a group constitute the best soils of the world for the production of oats and other cereals. More sandy soils do not produce as good a crop of oats as the loam soils, because the latter have a greater water holding capacity. The lighter soils will produce a satisfactory crop if the subsoil is fairly retentive of moisture and if they are well supplied with plant food. The best growth of the crop will not take place on heavy, poorly drained clays because of their tendency to be too wet and cold during most seasons. Soils that will retain and supply the crop with sufficient moisture and yet that are well drained should be used, but those that are poor in tilth and deficient in organic matter as well as those poorly drained are not adapted to oat production. When the crop is grown on very rich, undrained soils, lodging is normally bad and injury from plant diseases such as rust and mildew are more prevalent.

One reason for the necessity of soils with a high water holding capacity and of a growing season amply supplied with precipitation is that the oat plant requires more water per pound of dry matter produced than any of the other important cereals.

Economic Factors. The economic position of oats as a small grain crop has been rather uncertain since the replacement of large numbers of horses by mechanical power. Its profitability as a cash crop has disappeared, but it still has a place because of its ability to fit into rotations and its relative greater yield of grain on the very poor soils.

Morgan is of the opinion that the crop is a very strong feeder and that a fair crop can be produced on soils too poor for other crops. Furthermore, its value as a feed for breeding stock is superior to that of corn; oats are relatively richer in protein and mineral matter. They have no place in a fat stock ration because they contain more crude fiber than any of the other common feed grains.

Only about three per cent of the total oat crop is used as a human food, consequently the location of its production areas has no direct relationship with population centers. Some oat shipments are made about the country for horse feed, but this is seldom done for other classes of livestock. Oats are bulky with a resulting high freight cost per unit value. The tendency, therefore, will be consumed. The normal situation is for the farmer to raise very little more than he can utilize on his own farm. He will raise the crop because of its supplementary values as previously discussed instead of for any specific need for the crop as feed. An oat crop can be planted before the corn ground demands attention and can be harvested after the corn crop has been laid by. Very little soil preparation is necessary. The farmer can get considerable feed and straw, can utilize labor and can provide a nurse crop for a grass or legume crop with very little additional cost to his operations.

The distribution of the principal spring oat varieties is shown in Figure 10.

41. Ibid., p. 488 - 489.
Figure 10. Distribution of spring oat varieties in the United States in 1919.
Fall-Sown Oat Production. The oat crop in the United States consists of fall-sown and spring sown crops. About 2,500,000 to 3,000,000 of the total acreage of 35 to 40 million acres of oats sown annually in the United States are fall-sown. Winter-killing causes considerable fluctuation in the ratio between the harvested fall-sown and spring sown crops especially in the northern part of the fall oat regions. Severe damage may be done to a crop by winter-killing and farmers will temporarily abandon the fall crop for spring oats. Later on after a few favorable years the acreage of fall oats will increase rapidly until it is again retarded by abnormally low temperatures.

Figure 11 shows that part of the southeastern portion of the United States in which a comparatively sure crop of fall oats can be expected and that part where they may be grown in only the more favorable years.

Figure 11. Fall-sown oats in Southeastern United States. The crop is comparatively sure in the heavily shaded portion, but a crop may be grown in only the more favorable years in the lighter shaded area.


According to Stanton, fall-sewn grains have a three-fold advantage in the South; they provide a winter soil covering, a grain crop and some winter pasturage. Fall-sewn oats usually produce larger yields of a better quality grain and more forage than do the spring oats. This is because the fall oats grow more vigorously and mature from ten days to two weeks earlier than the others. Injury from heat, drought, and storms, as well as from rust and other diseases, which frequently makes the difference between success or failure, is sidestepped by this earlier maturity. Grain development takes place much better when the temperature is cool and if the cooler part of the spring months can be utilized by fall sowing with fair safety it should be done.

A well drained soil is necessary to prevent winter killing. Soils that are low, heavy, and poorly drained are particularly susceptible to heaving. The other chief cause of winter killing is the occurrence of a prolonged period of low temperatures in the absence of a snow covering. Areas where alternate freezing and thawing of the soil are frequent in late winter and early spring undergo considerable loss from winter killing, but such loss is less on sandy loams than on clays especially if there is sufficient organic matter to insure sufficient water holding capacity in the former. Rust and other diseases are more common when the crop is grown on naturally low, wet soils.

One of the chief drawbacks to fall oats is its place in the rotation. Many farms find it inconvenient to remove the previous row crop in time to permit the fall seeding of the crop. On the other hand, a cold, wet spring often delays spring oat seeding until the work interferes with that of the

44. Ibid, p. 3 - 4.
other crops, or until the maturity of the crop will come so late as to be severely injured by the hot weather. Normally more care and attention may be given to the seed bed preparation if the previous crop is removed sufficiently early.

Stanton and Salmon agree that the isotherm of 30 degrees marks the northern limit of successful fall oat seeding. The area between 30 degrees and 20 degrees is a transitory one in which both fall and spring oats are grown, but it is one where only the hardier fall sown varieties succeed consistently. The limiting factor of fall oat production, therefore, is the severity of the winters.

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The fourth most important cereal in the United States is barley.

The area of profitable production of this crop is more limited than that for corn, oats, or wheat; yet it is exceptionally well adapted to certain regions in which it has become one of the most profitable crops. Figure 12 shows the distribution of the crop. In some localities well suited to its culture, its value is not fully realized.  

![Barley Production in the United States in 1919](image)

**Figure 12.** Barley production in the United States in 1919. The heavy broken line divides the country into three general regions of barley production, the northeast or humid-spring region, the southeast or humid winter region and the west or semiarid region.


**Competition With Oats.** Harlan states that in all the principal barley-growing States and parts of States, barley is more profitable and produces more pounds to the acre than oats. Table III. shows a

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Table III.

AVERAGE ACREAGE AND YIELDS OF BARLEY AND OATS WITH THE CALCULATIONS OF TOTAL DIGESTIBLE NUTRIENTS, IN 35 STATES, 1922, 1923, 1924.

<table>
<thead>
<tr>
<th>State</th>
<th>Barley Pounds</th>
<th>Oats Pounds</th>
<th>Barley Total Digestible Nutrients</th>
<th>Oats Total Digestible Nutrients</th>
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<tr>
<td>Maine</td>
<td>4</td>
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<td>1544</td>
<td>1194</td>
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<tr>
<td>Vermont</td>
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<td>73</td>
<td>1440</td>
<td>1142</td>
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<td>1007</td>
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<td>1046</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>12</td>
<td>1123</td>
<td>1190</td>
<td>1056</td>
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<td>59</td>
<td>1698</td>
<td>1002</td>
</tr>
<tr>
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<td>10</td>
<td>172</td>
<td>1306</td>
<td>698</td>
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<td>1094</td>
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<td>1042</td>
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<td>1430</td>
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</tr>
<tr>
<td>California</td>
<td>909</td>
<td>127</td>
<td>1291</td>
<td>970</td>
</tr>
</tbody>
</table>

Source: Harlan, H. V. J. Barley Plant Culture, Uses and Varieties, U. S. D. A. Farmers' Bulletin No. 1494, p. 4, Table I.
comparison between the average acreage and yields of barley and oats for 1922, 1923 and 1924. A comparison is made between oats and barley because they are generally competitive. When corn can be grown profitably it produces more feed than either oats or barley; consequently, it will be the major feed crop of such areas. In regions west and north of the limits of profitable corn culture, barley tends to take its place. Wheat is not a competitor because its use as a food furnishes it with a cash outlet that is normally more profitable than its outlet as a feed would be. Labor distribution and rotation fitness of oats and barley bring them even closer together as competitors for a place where both can be grown. Both are normally spring sown and both are feed crops. It is true that some barley is used for malting purposes, but the excess must be marketed through livestock. Figure 13 shows the area in the United States in which the climate is relatively favorable for the production of barley. The shaded area indicates this. Within this area the well-drained yet not sandy soils should produce more feed per acre of barley than of either oats or wheat. Corn is a competitor only along the southern edge of the shaded area. Barley often can be substituted quite profitably for oats in the shaded area. Scattered local regions of the South are well adapted to barley.49

49. Ibid, p. 5.
Figure 18. Regions in the United States with a climate relatively favorable to barley. Area shaded is that part of the United States in which the climate is relatively favorable to barley production.

Causes of Small Barley Acreage. Two causes are largely responsible for the fact that barley is not more widely grown; in the first place farmers and feeders have failed to appreciate its value as a stock feed and its ears make it more disagreeable to handle, and in the second place the brewers have dominated the eastern markets paying premiums for the best quality grain and for varieties that are inferior as stock feed. This has resulted in causing the buyers and the farmers to look upon barley as an inferior feed substitute. Barley has, therefore, a definite place in the small grain enterprises on the farm in competition with oats.

50. Ibid, pp. 4 - 5.
Climatic Factors. Spring barleys, according to Hughes and Henson, attain the widest latitude and the highest altitude of all cereals. The winter varieties are not particularly hardy but they are more so than winter oats. The crop generally does best in regions of cool summers where the conditions are not too humid. It does well under semiarid conditions in tropical sections if there is sufficient water available for growth.

Soil. Poorly drained soils should not be used for barley; porous ones are preferred. Yet heavy soils produce good crops with good drainage or light rainfall. Sandy soils give poor results even though they are well drained. The best yields come from well drained clay loams. Barley does quite satisfactorily on rich, new land and it is more profitable than wheat on older lands that are not too light and that are well drained.

Economic Factors. Barley is a bulky product in comparison to its value; consequently it can be shipped only a small distance for feed purposes. That part of the crop, however, that goes into malt or into breakfast foods can be shipped greater distances.

The quick maturity of barley makes it adaptable to regions where it would not be grown otherwise. If the spring is too short for the maturity of spring oats or spring wheat, or if other crops demand the labor in the early part of the season, barley may be seeded later. The highest yields come from early seedings, but the quick maturity allows it to be sown late where few other crops would succeed.

52. Harlan, H. V., op. cit., p. 7.
Because of the rapid growth and early maturity of barley, it is often used as a catch-crop where the winter wheat crop has failed or where the season has become too late for a profitable spring wheat seeding in the spring wheat region. In such regions as Kansas where the winter wheat cannot be properly sown in season, or where the lack of moisture may prohibit proper germination, or where the crop winterkills, barley has attained an important place as a secondary crop suited to fill in abnormal conditions.  

Besides the value of barley grain as a feed, the straw for feed is practically as good as that of oats and much better than wheat straw. The luxuriant growth of barley combined with its early maturity makes it a good crop to use in weed eradication. Barley will succeed on stronger alkali soils than the other cereals.

Winter Barley. Winter barley is used to get a longer growing season in the South. Here it finds very favorable climatic conditions in the mountain areas, especially in eastern Tennessee. It has been much more profitable than oats in the parts of Kentucky and Tennessee where physical conditions are favorable. This situation may be altered, however, by inroads of the Hessian fly, because barley must be sown before the fly-free date. The isotherm of 20 degrees marks the northern limit of winter barley production. This apparently bears a close relationship to the daily minimum winter temperature of 20 degrees.

Besides the increased yields resulting from the fall seeding and the greater certainty of a crop in hot, dry years, the crop serves as a winter

cover crop which furnishes a grain and considerable winter pasture. A barley pasture is considered to be more palatable than that of the other important small grains. 58

V. Rye.

Rye can be grown in practically all parts of the United States, but its culture is limited because other crops are more profitable. Figure 14 shows the distribution of rye production in the country for 1919. It is more profitable in the Northern and Eastern States than in the remainder of the United States. 59

Figure 14. Rye production in the United States in 1929. Source: Martin, John H., and Smith, Ralph W., Growing Rye in the Western Half of the United States, U. S. D. A. Farmers' Bulletin No. 1369, Figure 3, p. 5.

Climatic Factors. Winter rye, the hardest and earliest of all cereals, successfully survives such winters as those in the extremely cold sections of northern North Dakota and Montana. This extreme earliness frequently permits it to escape the injury of droughts and rust. It can be successfully sown at a later date than wheat because it sprouts more quickly and grows more vigorously than wheat at low temperatures. Rye is more certain than other grain crops in arid and frosty regions such as the Great Basin of Northwest United States. A comparison of Figure 14 with 6 and 9 shows that the winter rye belt is about 300 miles north of the winter wheat belt.

Figure 15 shows the effects of severe winters upon winter rye as compared to winter wheat. The rye in plat 2 has made a vigorous growth while the winter wheat in plat 3 is practically a complete failure. Some idea of the earliness of the rye in comparison to spring wheat also can be secured by comparing plates 1 and 2.

Figure 15. Plats of spring wheat (1), winter rye (2), and winter wheat (3) in western South Dakota. Source: Martin, J. H. and Smith, R. W., Growing Rye in the Western Half of the United States, U. S. D. A. Farmers' Bulletin No. 1858, Figure 4, p. 5.

60. Ibid., pp. 3-5.
Soils. Light, sandy soils, acid soils, poor, thin land and poorly prepared seed beds will give better returns from rye than from the other small grains. Rye will respond to better conditions and better treatment with increased yields, but when such conditions do not exist fair returns may be expected. Rye is better adapted to the lighter loams and sandy soils than it is to the heavier clay soils; the best yields and the best quality grain are found coming from well-drained loam soils in which there is a good supply of lime. Such conditions are not necessary for rye does about as well on acid as on nonacid soils. It is probably the best grain for sandy, or rough, or exposed land. It does much better on sandy and poor soils than wheat and can stand more acidity in the soil than wheat, oats or barley. Rye should generally be the first crop on heath land, drained marshland, and out-over land being brought under cultivation. Lands subject to overflow or on which water stands after rains are not suited to rye culture. Severe lodging occurs on lands rich in nitrogen. Wheat generally does better on rich lands than rye, but on poor lands the condition is reversed.

Economic Factors. Rye has a distinct place in the farming system of the United States. It is primarily a bread grain second in importance only to wheat. The greater palatability of wheat bread at least according to the standards of the people in the United States, and the greater ease in milling and working with wheat flour has made it more attractive to the American consumer. The production of rye for grain, therefore, is limited

61. Ibid., p. 3.
to a great extent in this country. In regions where the conditions are favorable to wheat production, rye will be excluded because of the less demand and the smaller yields that can be expected as compared to wheat. On the other hand, there is considerable need for the expansion of rye into those regions generally unfavorable to wheat where it will give a greater yield of food per acre than will the wheat now being produced in such regions. Much of the sandy, sour and thin land of the Cotton Belt, as well as many other parts of the country where the climatic and soil conditions are generally unfavorable to wheat production, could be used effectively for rye culture provided the people will consume rye bread.63

Rye production deserves consideration because of its ability to utilize labor. In the spring wheat region it is sown in the fall with little or no seedbed preparation when the available labor and power would be idle otherwise, and it can be harvested before the wheat demands the time of the farmer. Rye can be sown later than winter wheat because of its quick germination; this means that if the farmer is delayed too much in getting out his wheat crop he can fall back on rye as a substitute, or he may expand his operations by seeding the rye after the wheat is sown, or he may wish to use the rye because it may be sown before wheat as there is little danger of the Hessian fly attacking rye. The regions where the Hessian fly is worst (the warmer parts of the country) also has much acid land on which rye will do better than wheat.64 It is less susceptible to rust and drought.

Rye is frequently employed as a winter cover crop and as a green-manure crop where green-manuring is a profitable practice. It can be sown on poor soil or on a poorly prepared seedbed, either alone or in mixtures with some legume such as vetch, without much expense. Its large vigorous growth in the fall permits heavier fall pasturing than wheat. A good growth is made in the spring and it can be pastured until the crop is almost mature. Spring rye sown in the summer makes abundant fall pasture where soil moisture and climatic conditions are favorable. Rye makes a fair nurse crop for legumes because it matures early enough to avoid smothering the legume crop. Its rank growth and its heavy draft on soil moisture and fertility make it less desirable as a nurse crop than barley or early oats under certain conditions. The rank growth, on the other hand, combined with heavy tillering and early vigor make it useful as a smother crop to keep down weeds. \(^6\)

The tendency of rye to volunteer from the easily shattered seed is one disadvantage discouraging its use in areas where small grains are grown exclusively. It matures the earliest and will shatter out enough seed to keep the field infested unless an intertilled crop is grown. Wheat should not directly follow rye because a mixture containing rye in appreciable amounts lowers the market grade and incidentally the price of wheat. Another menace from sowing rye in a grain stubble is the increased grasshopper infestation; this has, however, been greatly over-emphasized, especially in regions where there is enough grass land to provide ample

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nesting places for the grasshopper eggs. A final fault is that rye is more easily damaged by hail than wheat, oats, or barley, and the heads are more likely to be blasted by hot drying winds at blossoming time.\(^{66}\)

There will never be a great outlet for rye by feeding it to livestock because of its tendency to form a pasty mass when it is moistened in the process of chewing which causes the animal eating it considerable difficulty. It can be fed satisfactorily to horses, cattle and sheep, but there is no particular advantage in its favor; its palatability is considerably less than that of corn, barley and oats. Rye should never form more than one-third of the ration. Hogs have considerable trouble in swallowing ground rye, and if it is to be fed to them, it should be combined with other grains.\(^{67}\)

Rye is a valuable soilng crop, because it yields well and is ready for use early in the spring when pastures are too young and other feeds are generally scarce. It fits into the dairy regions quite well. A fair silage can be made from rye if cut when the grain is in the late milk stage. Rye straw has considerable value for packing furniture, crockery and nursery stock and for manufacturing such articles as horse collars and drinking straws.\(^{68}\)

\(^{66}\) Ibid, p. 3.
\(^{67}\) Ball, C. H., et al., op. cit., p. 511
\(^{68}\) Leighty, C. E., "The Place of Rye in American Agriculture", op. cit., p. 178 - 182.
VI. Grain Sorghums.

Sorghums are quite important as a grain crop in parts of the United States; the leading area is that of western Texas and Oklahoma. Several groups, each having a different name and each containing several varieties, are classed as grain sorghums. They are closely related botanically and are similar in general appearance, culture and use. The more important groups are milo, ka'fir and durra (including Paterita). The grain sorghums are of little importance when compared with the major cereal crops grown more widely throughout the United States. Yet they have tremendous importance in regions such as the southern part of the Great Plains (including parts of Kansas, Oklahoma, Texas and New Mexico). They furnish the tilled grain crop in the rotation and they are the leading feed crop, grain, roughage and silage for the farm and range livestock in this territory where insufficient rainfall and drying winds make it impossible to grow corn to supply these needs.

Climatic Factors. Moisture and temperature are the chief factors affecting the production of the grain sorghums. They can be grown successfully where the effective rainfall is lower than that required by corn, but both germination and satisfactory growth demand higher temperatures than required by corn. They are much more sensitive than corn to low temperatures in soil and air during germination and early growth. The large areas of dry land where deficient moisture prevents profitable corn production to the north and west of the present producing area are not used for grain sorghums because the increasing elevation and latitude, or both, shorten the growing season enough to exclude them.

70. Ibid., p. 529 – 530.
Hughes and Henson state that sorghum is not so exacting in moisture requirements as it is in temperature relations. Successful growth is common in dry regions having 15 to 25 inches of rainfall; it is grown in such regions not because it will do better than it will under more moist conditions, but because it will do better than other crops under conditions of light rainfall.

Soils. Rothgeb states that grain sorghums will grow on almost any soil ranging in type from light, sandy soils to heavy clay loams. Other factors being equal, rich soils will produce greater yields than the poor ones; however, with good seed, right climatic conditions and proper cultural practices, good yields may be expected on either light or heavy soils. Light soils have an advantage in requiring less work than the heavier ones. The heavy soils puddle and bake more easily in wet weather and the light ones are subject to blowing if the surface is too fine.

Economic Factors. The grain sorghums cannot compete with corn in the more moist sections of the country. Corn holds its own even in regions where the yields of grain sorghum are higher because it is a more efficient feeding grain, is more easily harvested and is more safely stored and transported. Corn can be easily husked either from the row or shock and stored immediately in bins, but the sorghum heads must be cut and cured in the open before they can be binned in quantity. Even then the bins must be well ventilated to prevent heating. The shelled sorghum grain, if not clean from dirt and cracked kernels, will heat unless it is

Ball states that estimates show that only about 25% of the grain sorghum crop moves off the farm where grown and very little of this that leaves ever reaches the terminal markets because of local consumption. It is a feed crop and must compete with corn. The chief commercial uses are such that it must compete with corn, and that part which finds its way into the corn producing areas or the non-corn areas closer to the corn centers of production must be either cheaper or better than corn for the purpose desired. If it is cheaper, it must be sufficiently so to offset longer hauls and the lower feeding value (which is about 80 to 90 per cent of that of corn). The sorghum grains are smaller than corn and are better fitted for poultry feeds. A considerable part of the grain shipped both east and west ultimately finds its way into poultry feed. The center of grain sorghum production is nearer the far west livestock feeders than is the Corn Belt, consequently some of the grain shipped west doubtlessly is used in stock feeding. It would have some advantage in so far as freight is concerned. The crop may be used as a rough forage or hay crop in the moister climates where corn excludes its use as a grain feed. A considerable amount of grain sorghums is used for forage purposes.

Biological Factors. Some smut diseases attack grain sorghums in varying degrees. The damage is general in its location and it can be partially controlled. The sorghum midge has limited grain sorghum production in parts of Texas.

74. Ibid., pp. 580 - 581.
75. Ibid., p. 530.
VII. Buckwheat.

Buckwheat is a relatively unimportant crop in the United States. New York and Pennsylvania produced 67.5% of the entire crop in the United States in 1932.

Climatic Factors. Buckwheat is in general more exacting in its climatic requirements and less critical of soil conditions than the other grain crops. Its demand for a cool and moist climate, especially at blooming time, forces it to become more and more a crop only for the higher elevations as one moves from north to south. It is sensitive to high temperatures and to dry weather at blooming time; the damage becomes worse when the above conditions prevail both day and night or when they are accompanied with hot, drying winds. Even hot weather with constant rain is undesirable, because all or many of the flowers then in bloom may become blasted and produce no grain.

Contrary to what one might expect considering the damage of hot weather, buckwheat is very sensitive to cold, being killed when the temperature falls to freezing or at most 3 or 4 degrees below freezing. Its short growing season of only 10 or 12 weeks and the small amount of heat necessary for a complete growth of the crop allow it to be grown far north and at high altitudes.

Soil. Buckwheat is often able to produce a profitable yield on land too poor for wheat or even rye providing the climatic conditions are favorable. It is probably the best grain crop for poor, thin soils, but increased yields soon pay for a good treatment. Light well-drained soils, varying from sandy loams to silt loams, give the best results. The

78. Ibid., p. 5.
lime requirement is low; in fact, it seems to prefer an acid condition.79

Buckwheat has a distinct advantage over the other grains because the roots are of such available plant food in the soil. Cheaper fertilizers can also be used. The crop is no good for heavy wet soils. Rich lands, especially those high in nitrogen, cause severe lodging. Limestone soils are not well suited to buckwheat.80

Economic Factors. Buckwheat often can be used to supplement the farm business more completely utilizing the available labor and power. Its short growing season permits the postponement of the soil preparation and planting until after the other crops which must be planted early are already sown. Another factor which may merit its use is that it serves to make even very hard land mellow and friable, consequently it can be effectively used on such land before crops like potatoes.81

Buckwheat can be used for livestock feed and for bee pasture. Buckwheat flour is in fair demand. Some people plant the crop for ornamental purposes; its bloom is quite attractive. The acreage that can be utilized is limited because other crops produce a greater amount of feed and because the demand for flour is not exceptionally large.

Danger of Complete Loss. The fact that unfavorable weather conditions may seriously or even completely destroy the crop probably is the chief reason why buckwheat is not grown more universally. Correspondingly adverse conditions to other crops may result in only a partial loss. A few days of unfavorable weather during the flowering season is all that is necessary to get quite disappointing results. The unfavorable conditions

79. Ibid., p. 6.
80. Ibid., p. 6.
81. Ibid., p. 5.
often may be avoided by planting the crop at such a time that the principal growth will be in warm weather and the seed formation will be in the cooler weather of late summer. 82

VIII. Rice.

Rice is relatively unimportant in the United States as compared with either the world production or with the production of other cereals in the United States. Its greatest acreage in this country is found on portions of the Coastal Plain of the South Atlantic and Gulf States; it can be more profitably grown on these lowlands than any other crop for which there is a domestic demand. It is about the only source of income in southwestern Louisiana and southeastern Texas, where over 75% of the cultivated land in some of these parishes and counties is used for rice growing. 83

Physical Factors. Ball states that the principal physical factors affecting rice production are irrigation water, precipitation, temperature and soil, and of these irrigation water is the most important.

An abundant supply of fresh water is necessary because the land in rice must be submerged to a depth of approximately 6 inches of water throughout a period of at least 75 days. This makes necessary the availability of large quantities of water at all times during the growing season if maximum production is to be insured. 85

In connection with the matter of irrigation, the lay of the land must be such that it can be uniformly and easily submerged and drained. Ideal conditions would be land that is relatively flat near enough to a river

82. Ibid., pp. 5 - 6.
84. Ibid., p. 618.
85. Ibid., p. 618.
to furnish a cheap supply of water. The land should be high enough above the river to permit the necessary drainage.

**Climate.** Rice requires a relatively high humidity and a mean temperature of above 70 degrees during a growing season of 4 to 6 months. A rainfall of 50 to 60 inches well distributed throughout the year within rice area and upon the watershed of its streams is necessary to provide the needed irrigation water in dependable quantities. 86

**Soils.** Medium textured to rather heavy soils are the most productive rice soils. They must be underlain with a subsoil that is impervious to water if the irrigation water is to be held within the levees at the required depth. 87

Upland rice is sometimes grown without irrigation, but the yields are considerably less and a more ideal rainfall distribution is required.

86. Ibid, p. 618.  
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Cereal Crops. (Chapter II.)


CHAPTER III.

LEGUME CROPS

1. Alfalfa.

Alfalfa, one of the most important forage crops in the United States, is exceeded in acreage by only one other perennial crop grown for the same purpose; timothy, alone or mixed with red clover, has a greater acreage. Alfalfa must be a crop of increasing popularity, for the acreage has increased from 2,094,011 acres in 1899 to 11,516,811 acres in 1929. By far the greater part of the alfalfa acreage is in those states west of the Mississippi River, but the most rapid increase is east of this river and north of the Kentucky-Tennessee line. Nebraska, South Dakota, Colorado, California, Idaho, Montana and Kansas led in acreage in alfalfa in 1919. 1

Climatic Factors. Alfalfa, although it is suited to many conditions, is best adapted to irrigation farming in the arid regions. Bright, sunny days, little rainfall and a controlled water supply are favorable for growing the crop and for curing the hay. The soils of an arid region have not been leached out to the extent that those of a more humid region have, consequently those that occur in arid regions are generally as favorable to alfalfa as is the climate itself. 2

The highest yields of alfalfa in the United States are found in the regions of longest growing seasons. Southern Arizona and interior California, the regions with the longest periods of favorable summer weather in

2. Stewart, George, Alfalfa Growing in the United States and Canada, pp. 76 - 77.
the United States, normally produce six or eight cuttings of hay in a single summer. The crop can stand hot weather well, but it is seriously affected by the cold weather of winter and early spring; yet hardy strains are known to commonly resist temperatures of 30 degrees and 40 degrees below Fahrenheit zero in the Northwest. 3

Rainfall. Alfalfa is not ideally adapted to humid regions. Normally, it is not produced in regions of over 40 inches of rainfall with 20 to 30 inches being more favorable than 30 to 40 inches. It thrives for a few years along parts of the Gulf Coast in spite of more than 50 or 60 inches of rain annually. Greater difficulty in curing the hay accompanies the higher rainfall, especially where a major part of the precipitation comes during the summer months. A moderately high temperature accompanied by great humidity causes alfalfa to languish, while in dry climates only excessively high temperatures are injurious. Aggressive weeds which tend to smother the crop are favored by damp hot climates. 4

Altitude and Soils. Alfalfa succeeds at altitudes ranging from below sea level in the Imperial Valley, California to 8,000 feet above sea level in the mountains of Colorado. 5

Where other conditions are favorable, alfalfa has a very wide range of adaptation with respect to soils, but best results come from deep loams with open porous subsoils. Alfalfa ordinarily does not do well on soils with an impervious subsoil, hardpan, or bedrock near the surface; however, instances are known where growth was satisfactory on soils underlain at

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3. Ibid, pp. 77 - 78.
4. Ibid, pp. 80 - 81.
18 inches by limestone ledges. Rich river bottoms and soils of limestone origin are the soils of the eastern part of the United States best suited to alfalfa culture. In this part of the country where the climatic conditions are not generally favorable only the best soils give yields sufficiently great to merit their use for alfalfa. Little or no growth is made on the strongly alkali soils frequently found in the west.  

One reason for the great success of alfalfa in the arid regions of the western part of the country is the physical disintegration of rock in the soil formation. Free aeration of the soil at greater depths, permitted by the loose accumulation of coarser particles, results in a more complete oxidation of the minerals several feet below the surface. Oxidized minerals are more soluble and are in a form available to the plant. They are, therefore, made available in larger quantities and are leached away in smaller quantities in the arid regions; alfalfa does best where large quantities of lime, phosphorus, and sulfur are available.  

Next to drainage, the most important soil requirement of alfalfa is the matter of lime. Truog states that alfalfa has a very high lime requirement. None other of the common legumes tested by him had so high a requirement. Very few regions of Eastern United States that have been farmed for a few years will successfully produce alfalfa without the addition of limestone.

Organic matter is especially valuable to alfalfa because it supplies plant-food, increases the capacity of the soil to retain water, improves

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7. Stewart, George, op. cit., p. 83.
the tilth of compact soils by granulation, makes the mineral plant nutrients more available, leaves behind more available nitrogen, furnishes food for soil bacteria and causes the soil to warm up earlier in the spring. It is particularly beneficial in getting a new stand of alfalfa.9

**Drainage.** If alfalfa production is to be successful, good surface drainage and underdrainage are absolutely essential. Complete submergence of the plant for as long as 24 to 48 hours during the growing season will do considerable damage, but the plants may remain under water for several days with no serious results when they are dormant. Disastrous results may result from the formation of ice sheets on the field during the winter. Alfalfa rarely does well where the water table comes close to the surface, especially when the level of the water table fluctuates to a large extent.10

**Economic Factors.** All forage crops are normally too bulky in proportion to their value to be shipped long distances. Alfalfa, however, is often shipped from the west to the large dairy centers of the east in large quantities. Such hay is so expensive that only the more intensive livestock enterprises such as dairying, poultry and minor specialized interests (wealthy estates, pet farms and game farms) can afford to purchase it. A concentration of alfalfa acreage near population centers is an attempt of the dairymen to produce their own roughage. High yields of the best quality hay make alfalfa a profitable crop on the more expensive land near cities. Alfalfa is a more nearly perfect forage than

any other crop grown in the United States; it is unsurpassed as a general hay crop, it has a high carrying capacity and produces large gains as a pasture, it is valuable as a seiling crop if properly handled, an excellent silage can be made from it and it makes a good and easily handled feed when ground into meal. It is also highly regarded as a soil improver because of the favorable effect it produces on succeeding crops. It is only reasonable to expect, therefore, that there will be sufficient demand for the crop to encourage its production both in regions favorable for its production in spite of freight costs and in regions less favorable but near its point of consumption. Of course when the general price level is exceptionally low and the freight costs make up a relatively greater part of the hay cost to the consumer, the tendency will be to use more hays grown locally.

Two economic factors as well as those of a physical nature tend to discourage large acreages of alfalfa in the more humid parts of the United States where the choice of crops is quite large. The first is the matter of labor conflict and expense. A grain farmer attempting to introduce alfalfa finds that it interferes with the cultivation of his row crops and the harvesting of his small grains. If he has several acres of corn to cultivate and a crop of alfalfa needing mowing or already cut, a rainy spell will cause him considerable grief. While he is attempting to save the hay crop, his corn is rapidly becoming too large to cultivate. If he has a small acreage of alfalfa, the problem is much less serious and he can

usually overcome the conflict with little trouble; however, if he has a large acreage of alfalfa, the conflict becomes quite serious. A large amount of hay demands considerable labor at each cutting. If he attempts to hire this labor in large quantities as needed, he will have trouble sooner or later. Some farmers have attempted the production of alfalfa on a major scale having the most of their farm seeded to the crop. They cannot afford to carry a large crew for several months just to get a few weeks work and they usually do not have available supplementary work to utilize the labor. Such a farm as a general proposition is undesirable for the average farmer.12

The second undesirable factor is the matter of the lack of a place for alfalfa in a short rotation. The various clovers usually fit in much better. If the physical conditions are favorable, the crop can be worked into a rotation quite readily in a regular order; however, it is often much too difficult to get a stand to merit the trouble for only one or two years.

Livestock farms, which can use a large amount of hay, often employ a system whereby the field in alfalfa remains in that crop while the remaining fields make a complete circuit of the rotation, then that field becomes a part of the regular rotation and another is set aside for alfalfa. Quite often, however, a rotation field is so large that the farmer will not want that much hay or will not have available the needed labor. Grain farms can use a small field of alfalfa not in the rotation to provide the needed hay, thus leaving the entire legume crop

of the rotation for green manure purposes. The acreage of alfalfa in
the more humid regions, therefore, is largely limited to small fields
not a part of the regular farm rotation. In regions where the topo-
graphy and other physical factors often cause small, odd-shaped fields,
a field of alfalfa can be readily used to utilize such fields that
would be uneconomical for cultivated crops.

Biological Factors. Alfalfa is especially susceptible to the attacks
of weeds, diseases, insects, and animals; weeds constitute the worst
enemy of the crop in the most of the United States. Dodder, a yellow,
threadlike, parasitic plant, is very objectionable in the seed-produc-
ing areas of the country. Alfalfa seed containing dodder is very hard
if not impossible to sell, and the two seeds are very difficult to
separate. This weed seldom gives trouble in fields used for hay pro-
duction. Kentucky bluegrass and quackgrass are troublesome in the
northeastern part of the United States; crabgrass and Bermuda grass
bother in the Central and Southern States; and foxtail or wild millet
is bad in the Middle West and the Great Plains.

The most serious disease attacking alfalfa at the present time is
bacterial wilt. It is especially destructive in the best alfalfa
districts of the Middle West and West, and is much less prevalent in
the East. A stand of alfalfa seldom survives more than two or three
years where the disease is serious. Root rot, a fungous parasite upon
the roots of alfalfa, occurs from eastern Texas to southern California.
The greatest abundance of crown wart occurs in California, but it has

13. Westover, H. L., op. cit., p. 27.
been observed on the limestone soils of Mississippi and in many of the States west of the Mississippi River. "Alfalfa dwarf," which greatly resembles bacterial wilt, is quite serious in southern California. Other diseases such as leaf spot and yellow leaf blotch are not territorial in their attacks but are common in all large alfalfa-growing regions. 14

The grasshopper, which probably does more damage to alfalfa than any other insect, occurs in all parts of the United States but is most destructive in the arid and semiarid districts. Utah and the surrounding states are the center of the most destructive work of the alfalfa weevil. The leafhopper attacks, while they seldom kill the plants outright, are responsible for a material reduction in yields of alfalfa, particularly in the Eastern States. 15

Gophers, ground squirrels, prairie dogs, and mice are the most troublesome rodents encountered in alfalfa production. They are especially bad in the west where they eat the roots of the plants. 16

15. Ibid, pp. 28 - 29.
Sweet clover was regarded not only as a worthless field crop, but as a bad weed a few years ago. The expansion of its use has been tremendous, especially in the Corn Belt, during the last decade. Its widespread use is the result of the outstanding value of the crop as a pasture and soil improving crop, the relative cheapness of seed, and the ease with which it may be fitted into established cropping systems.\textsuperscript{17}

**Climatic Factors.** Sweet clover is adapted to southern Canada and practically all of the United States from a climatical standpoint, thriving equally well in semi-arid and in humid regions. It endures the summers of the South well and there is little or no winter-killing in severe winters in North Dakota when drilled or sown broadcast. It often does well in semi-arid regions too dry for alfalfa to succeed.\textsuperscript{18}

**Soil Requirements.** Sweet clover is one of the most cosmopolitan crops in its choice of soils. It thrives upon the adobe and granitic soils of the Pacific Coast, upon the gumbo, hardpan, prairie, and sandy soils of the western North-Central States, and upon the heavy clay, loam, limestone, and sandy soils of the southeastern states. In fact, all the principal soil types of the United States where the soils are not acid and are well inoculated will successfully produce the crop. It grows luxuriantly upon soils rich in calcium carbonate in many parts of the country where the lack of nitrogen and humus has caused many farms to

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\textsuperscript{18} Piper, C. V., *Forage Plants and Their Culture*, pp. 481 - 482.
be abandoned. Sweet clover thrives on newly exposed heavy clay soils and upon steep embankments where little else will grow. Poor drainage, overflow, and seepage are tolerated by the plant to a much greater extent than by alfalfa. Maximum growth, however, is to be expected only on well-drained soils. It does well on many soils which are not fertile enough to grow red clover or alfalfa. Sweet clover will grow successfully on soils which are apparently too alkaline for grains or alfalfa.

An abundance of lime is necessary in the soil if a maximum growth of sweet clover is to be secured. If the crop is to be sown on acid soils, an application of sufficient lime to neutralize this condition should precede the seeding. Truog states the lime requirement of sweet clover as being high. This is lower than alfalfa, but higher than all the other common clovers.

Natural soil inoculation need not be a factor limiting production areas, because quite successful commercial inoculators may be purchased quite reasonably.

Economic Factors. The primary purposes for which sweet clover is grown are for pasture and for soil improvement. It can be used as hay, as a soil-salting crop, and as silage; these uses are only incidental to the chief reasons for raising the crop. It is not a crop to be sold or shipped with the possible exception of seed, but as the seed is not bulky in relation to its value the matter of transportation is not a limiting or controlling factor. The economic factors influencing the choice of production areas are primarily those interior to the farm.

The farmer, in planning his rotation, wants a crop that will restore to the soil huge quantities of organic matter and nitrogen. If he is a grain farmer, he may not want to lose the use of his land for one year or he may be willing to let it stand in a soil improvement crop for a year. Sweet clover is probably the most valuable crop for either practice under most farm conditions. If he has livestock, he may want a pasture crop with a high carrying capacity. Sweet clover will meet this requirement quite satisfactorily. It is an excellent crop for either the grain farmer or the livestock farmer.

The crop can be seeded in the spring in a small grain and can be grazed lightly for two or three months in the fall. When it is pastured to full capacity, a good stand will carry from one to two animal units to the acre through the fall season without seriously injuring the crop. The second-year clover can be pastured considerably earlier in the spring than any other pasture crop in common use with the possible exception of bluegrass in certain areas. It will furnish more grazing per acre than any other pasture crop common in the Middle West. A maximum carrying capacity is about two or three animal units per acre, and cases are known in which as many as four animal units per acre have been carried for a period of 100 to 110 days. It sometimes happens that there is a few days gap between the grazing period of the old and the new crop. This is considerably less than the normal languishing of the other pasture crops during the summer.

The practice of seeding sweet clover in mixtures is used in many localities. In sections where the fields contain small areas lacking lime, thus preventing an even stand of sweet clover, the seeding of a mixture will fill in the skips. Other clovers and grasses also serve to give variety to the pasture diet, lessens the loss from bloat, helps to bridge over the gap that may occur between the grazing season of the first year and second year crop, and lengthens the grazing season if the crop is grazed through the fall of the second year. Grass roots also tend to protect the sweet clover from heaving on soils susceptible to this damage and to permit a better job of fall plowing on loose, porous soils after the pasture season is over. 22

Sweet clover, therefore, has a place in the rotation of both grain and livestock farms. Of course, if an area has a soil with an exceptionally high organic matter that does not become readily depleted and if the area has a surplus of permanent pasture land not suited to crops, sweet clover may be of no value; such sections, however, are hard to find. Regions where the soil is quite acid and where lime is too expensive will find some other crop to be profitable.

22. Ibid, p. 5.
Red clover, one of the most important and most widely known of all cultivated legumes, is grown throughout northern and central North America and Europe. Some idea of its distribution in the United States can be secured from Figure 16.

![Clover Acreage, 1919](image)

**Figure 16.** Acreage of clover grown alone in the United States, 1919.

**Source:** Pieters, A. J. and Walton, W. R., *Red-clover Culture*, U. S. D. A. Farmers' Bulletin No. 1339, Figure 1, p. 2.

(a) "Clover" may mean red, mammoth, or alsike clover in the Northern and Central States; crimson clover in the Coastal Plain of Delaware, Maryland, and Virginia; bur clover in parts of the South; and it was specifically stated in the census schedule to include lespedeza.

A large amount of red clover is grown as a mixture with timothy. Figure 17 shows the distribution of timothy and clover mixed in the United States. Part of the clover is alsike clover, but the largest proportion is red clover.

Figure 17. Acreage of timothy and clover mixed in the United States in 1919.
Source: Pieters, A. J. and Walton, W. R.,
Red-clover Culture, U. S. D. A. Farmers' Bulletin
No. 1339, Figure 10, p. 16.
Red clover is adapted primarily to growing in rotations with other crops, therefore, it has been used largely in those regions where a variety of crops are grown. An increasing difficulty of successfully maintaining stands of the crop is becoming a serious problem for the American farmer. Continuous cropping and the consequent reduction of the humus and plant food in the soil has increased greatly the difficulty of growing red clover.24

Climatic Factors. Piper25 states that the data showing the heat tolerance and cold resistance of red clover is not definite. Red clover is probably more cold resistant than alfalfa, because it endures well the winters of Nova Scotia, Maine, and Minnesota. The crop succeeds only if planted in the fall and all the plants usually disappear by the following August in the Southernmost States. It is distinctly a crop for humid regions without excessive heat or cold.

Soil. Red clover is exacting in its soil requirements. Rich clayey soils containing an abundance of lime give the best results, but tough clays are very unfavorable partly on account of their undrained condition. Light soils are generally unsatisfactory. A soil with a good content of humus is desirable. Deep soils enable the plant to develop its extensive root system. Soil-moisture conditions are quite important, because the crop will not thrive on sandy or gravelly soils that become droughty, and it is especially intolerant of waterlogged or poorly drained soils.26 Potash and phosphorus should be present in the

soil in fairly liberal quantities as the crop draws rather heavily on them. 27

28 Truog classifies red clover as having a medium plus lime requirement. This is slightly less than that of sweet clover but higher than the other clovers.

Many orchardists attempt to use red clover as a cover crop, but it does not thrive well in shaded places and mostly disappears after the first season. 29

Economic Factors. Red clover is used primarily for hay, as a rotation pasture, and for soil improvement purposes. It may be used at times as a soil ing crop or for silage, but these uses are unimportant. In spite of the fact that alfalfa is a better hay crop and sweet clover has a higher pasture carrying capacity and a greater soil improvement ability, red clover is grown largely because of its general utility in the rotation. It makes a better quality hay than sweet clover. It fits into the normal farm rotation much better than alfalfa. Although it may not be the best for either of its three uses, it usually gives good returns when all three are expected from the same crop. Red clover usually conflicts much less with other crops for labor than does alfalfa.

Because of its cheaper value per unit of weight, red clover hay is shipped much less than alfalfa hay. The majority of the hay is fed within the community where it is grown. Large quantities of mixed clover and timothy hay were formerly used for horse feed, but much of this market has disappeared. The dairy industry is increasing with a

29 Piper, C. V., op. cit., p. 415.
resultant increasing demand for hay, but alfalfa is generally preferred by the dairymen.

**Biological Factors.** The clover producing states east of the Mississippi River must contend with the clover root-borer. It threatened the entire red clover-growing industry of Michigan at one time, and it is becoming to be a serious menace to the crop in western Oregon and Washington where red clover is of considerable importance. The clover-seed chalcis fly, the clover-flower midge, and the clover leaf-weevil also do serious damage; they are not territorial but general in their location. The fly is one of the worst clover enemies in the United States at the present.30

A fungous disease, clover anthracnose, is especially disastrous in East-Central United States. Although it has been reported from practically all parts of the clover belt, it is doing its greatest damage in the South.31 It is probably the chief cause of many of the clover failures. Figure 16 shows the area of severe anthracnose trouble in the eastern portion of the United States.

Dodder, buckhorn, foxtail, and crabgrass are probably the worst weeds which interfere with red clover.32 Areas where these weeds are prevalent have extreme difficulty in selling seed and some difficulty in selling hay.

Figure 18. Area of severe anthracnose trouble in Eastern United States. Anthracnose is severe in all the shaded area.

Source: Pieters, A. J. and Monteith, John, Jr., Anthracnose as a Cause of Red Clover Failure in the Southern Part of the Clover Belt, U. S. D. A. Farmers' Bulletin No. 1510, Figure 1, p. 2.
IV. Mammoth Clover.

Mammoth clover is a variety of red clover that is often hard to distinguish from the medium variety commonly called red clover. Mammoth clover produces only one crop of hay, but that crop is usually larger than a single cutting of medium red clover. The quality of hay, however, is often inferior because it makes larger, coarser stems that tend to be woody and because it lodges badly thus causing part of the plant to deteriorate on the ground. It is perhaps a little more certain to produce a crop on a poor soil and particularly on a sandy soil than medium varieties. It has, according to Truog, a medium lime requirement; note that this is somewhat less than that of medium red clover.

V. Alsike Clover.

Substitute for Red Clover. When red clover, the standard leguminous rotation crop of the northeastern part of the country, cannot be grown because of low, wet land and soils that are low in lime content or that have been run down by long and unwise cultivation, alsike clover often can well replace it. Alsike clover seed is often cheaper than red clover seed, and less is needed per acre. When the latter is exceptionally high in price alsike clover can be substituted

34. Truog, Emil, op. cit., p. 21.
profitably on many soils. Figure 19 shows the area in which alsike clover is grown.

Figure 19. Area in which alsike clover is grown in the United States. The black area shows where it is grown more or less regularly as a forage or seed crop; the hatched area shows where it is rarely grown or only in special places. Source: Pieters, A. J., Alsike Clover, U. S. D. A. Farmers’ Bulletin No. 1151, Figure 2, p. 3.

Climate. Alsike clover does best in a cool climate such as that found in its home, the Scandinavian Peninsula. It withstands severe winters better than red clover and thrives best in regions where the summers are cool. It is less successful in Southern United States, thriving only where an abundance of moisture enables it to overcome the injurious effects of the warm summers. It is almost unknown in the Southern States other than Virginia, Kentucky, Tennessee, and Missouri where it is grown to a limited extent.

Soil. A rather heavy silt or clay soil with plenty of moisture gives the best results with alsike clover. It will thrive on good loams, but it usually does not do well on dry, sandy, or gravelly soils. The crop grows luxuriantly on rich, moist bottom lands. Although it responds well to lime treatments, it is not as sensitive to acidity as is red clover, and it can be successfully grown on many wet, cold, and "sour" soils on which red clover is a failure.\(^{37}\) The ability of alsike clover to withstand waterlogged conditions is shown in Figure 20. This crop will thrive luxuriantly with the crowns and roots under water.

Figure 20. Ability of Alsike clover to endure water. The plant at the right has been growing in a pot completely submerged in water for a year; that at the left grew under normal conditions. Source: Pisters, A. J., Alsike Clover. U. S. D. A. Farmers' Bulletin No. 1161, Figure 6, p. 14.

Truog\(^{38}\) states that alsike clover has a lime requirement of low plus as compared with medium plus for red clover. This substantiates the previous statement concerning the ability of alsike clover to

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37. Ibid., p. 3.
thrive under conditions too acid for red clover.

Economic Factors. The economic position of alsike clover is that of a substitute for red clover. It produces less hay and pasture and a smaller amount of fertility than red clover under favorable conditions for both. Care must be used in utilizing the crop as pasture because of its tendency to cause sores on horses and mules. It is especially valuable for permanent pasture on low or "sour" land either alone or mixed with redtop. When sown with red clover, a yield which is said to be greater than that from either variety alone is to be expected. It is seldom grown alone for hay. Some farmers get an exceptionally good hay when it is mixed with timothy. One advantage of the presence of timothy or some other grass crop is its tendency to hold up the alsike plant on rich, moist land.

Biological Factors. Pieters states that alsike clover is not seriously, if at all, affected with diseases such as trouble red clover. It seems immune to anthracnose which wrecked the red clover plantings in certain sections. Except for the clover aphids in Idaho, a similar statement may be made in regard to insects.

40. Ibid., p. 16.
VI. Crimson Clover.

Crimson clover is an important annual or winter annual crop in the lighter sandy areas of the Atlantic Coastal Plain. Figure 21 shows the part of the United States where the crop is more widely grown.

![Map of United States showing areas of crimson clover cultivation](image)

Figure 21. Regions in the United States where crimson clover is most widely grown (shaded). Source: Kephart, L. W., Growing Crimson Clover, U. S. D. A. Farmers' Bulletin No. 1125, Figure B, p. 5.

**Climatic Factors.** Crimson clover does not withstand either extreme heat or extreme cold, and it is grown in regions which enjoy at some time during the year a long period of relatively mild, moist weather. It ordinarily does not withstand winters in latitudes north of southern Pennsylvanias, and it is frequently killed by dry, hot weather common in the fall or spring of many of the Southern States. If the summers are not too hot, it can be planted in the spring and grown as a summer crop, but other clovers are usually preferred for
this purpose.

Soil. Almost any type of soil, if it is reasonably rich, well drained, and supplied with organic matter and the proper inoculating bacteria, will successfully grow crimson clover. A large part of the crimson clover acreage is found on the sandy soils of the Atlantic Coastal Plain, but it is not necessarily restricted to sandy soils. The crop is increasing in importance on the red-clay soils of the Piedmont region and in the limestone valleys of Virginia and Tennessee. It has been used quite effectively to build up soils that have been abused, but it is not a crop for land that is naturally poor. Crimson clover will do no good on rough, newly cleared areas, raw subsoil, hard, dry clay, or sterile sand. It is a crop for maintaining soils already in a good state of productivity rather than one to grow on poor soils. Figure 22 shows the effect of a lack of humus on a stand of crimson clover. Truog states that the lime requirement of crimson clover is low plus.

Economic Factors. The exact place for crimson clover in the farm plan is rather indefinite. It may be used as a hay crop, a winter pasture, a winter cover crop, or a soil building crop. Its use as a hay crop depends upon whether some other legume that is higher yielding or that is better fitted to the rotations being used is more desirable. The clover can be seeded in corn or some other intertillled crop at or shortly before the last cultivation. It may be plowed under or mowed before time to plant the corn the next spring. Such a procedure pro-

42. Ibid, pp. 9 - 10.
43. Truong, Emil, op. cit., p. 21.
Figure 22. A crimson clover failure on ground too poor in humus.
Source: Kephart, L. W., Growing Crimson Clover, U. S. D. A.
Farmers' Bulletin No. 1142, Figure 4, p. 9.

...vides a summer cash crop and a winter soil restorative crop the
same year. The success of such a plan, however, depends upon the
possibility of getting a stand of clover. The intertilled crop
quite often requires and gets most of the moisture, thus causing
the young clover plant to succumb. Furthermore, because there is
likely to be too much hot weather after the corn is laid by south
of central Virginia, the seeding should be delayed. 44

44. Kephart, L. W., op. cit., pp. 6 - 7.
The risk of getting a stand because of the droughty climatic conditions greatly limits such a procedure.

If crimson clover is seeded too early either it will be too big to withstand the winter or it will be killed by hot weather. If planted too late, it will make insufficient growth to stand the winter. It must be sown in the latter part of August or early September for good results. To insure proper soil moisture conditions, the soil should be worked down into a good seedbed. Very few crops other than the small grains and some of the truck crops are removed in time to permit such a procedure. In some sections, tobacco or shock corn are removed in time to permit its use. If a small grain is included in the rotation, a spring sown legume such as sweet clover can be used quite profitably. If a seed bed is prepared in time for crimson clover, a more profitable legume that need not be plowed up the next spring could be seeded. It can be used as a winter cover crop in orchards quite effectively.

VII. White Clover.

Climatic Factors. White clover, a long-lived but shallow-rooted perennial, is adapted to moist soils in nearly the whole temperate zone. In North America, it ranges from the northern limits of agriculture southward to the Gulf of Mexico. It thrives best in cool, moist climates. The plant apparently disappears during the hot weather in the South, but it quickly becomes abundant again in the fall.\footnote{45. Piper, C. V., \textit{op. cit.}, pp. 474 - 475.}
Soils. White clover will grow on any sort of soil that contains an abundance of moisture, but it does best on loams and clay loams rich in humus and fairly well drained. It is so well adapted that it holds its own spontaneously through all the moister areas in America. It gradually becomes more abundant in old pastures unless the soil is poor or droughty. Phosphate and potash have considerable effect upon white clover.46 Its lime requirement, according to Truog,47 is low.

Economic Factors. Other than bluegrass and possibly Bermuda grass and redtop, white clover is the most important perennial pasture plant in America. Most bluegrass pastures contain large quantities of it, but it is not abundant in the best bluegrass areas. It makes up an important part of mixed pastures and is more important than bluegrass in the Cotton Belt. The crop grows well in shady places and often makes up a considerable part of the ground cover in orchards. Lawn mixtures often contain large quantities of the plant.48

46. Ibid, pp. 475 - 476.
47. Truog, Emil, op. cit., p. 21.
VIII. Bur-clover.

Bur-clover, a winter annual legume, is highly regarded particularly because it so readily maintains itself with little or no reseeding, and because each year it can be depended upon to add humus and nitrogen to the soil without sacrificing the regular summer crop of the farm. It is the cheapest legume that serves as a winter cover crop, thus preventing the washing of the soil; in addition it furnishes some pasturage and improves the soil.

Climatic Factors. Bur-clover, because of its normal growth during the fall, winter, and early spring and maturity early in the summer, is adapted primarily to regions with mild, moist winters. The crop maintains itself only in those areas shown by Figure 25. Northward from the shaded areas, the crop succeeds fairly well when the seed is sown in the spring, but it is scarcely able to maintain itself by reseeding from year to year.

Soils. Loam soils are most suitable to bur-clover, but it will succeed on practically all types of soil. Best growth is made on soils rich in lime, but the plants thrive well enough in soils lacking a high content of lime. It normally prefers moist, well-drained soils, but in regions such as those in California, it grows vigorously on the often poorly drained adobe soils. The plants mature much later on moist soils than on those that are well drained. Apparently, bur-clover is as tolerant of alkali conditions as is barley; normally, it

50. Ibid, p. 5.
succeeds well in slightly alkaline soils, but not those heavily charged with salts. 51

Economic Factors. One advantage of bur-clover over most other legumes is that good stands often can be obtained from year to year without additional seeding. It will reseed itself indefinitely on pasture lands after it is once established. On cultivated land, intertilled crops such as corn and cotton commonly occupy the land too long each season to make practical the use of bur-clover, but it can be used quite well in wide rows. A combination of bur-clover and Bermuda grass is very satisfactory as a pasture. The grass provides warm weather pasture and the clover comes in during the cooler weather of spring and fall. Farm animals do not eat the plant readily at first, but they soon acquire a taste for it. It is commonly used as a green manure crop in the orchards of California. In the South, its

51 Ibid, p. 5.
greatest value is that it is the cheapest and most easily handled
legume that can be used as a combination cover and green-manure crop.
It adds each year a reasonable amount of humus and nitrogen when
allowed to reseed itself in a cropping system made up of cotton alone
through the summer. It does not require the loss of a growing season
of the cash crop, and the fertility added each year in the end gives
more satisfactory results than turning under a large green-manure
crop at long intervals. Bur-clover hay is not regarded very highly,
consequently it is used for this purpose only when necessary.

IX. Lespedeza.

Lespedeza, also often called Japan clover, is one of the most
valuable forage crops for the Southeastern States. The regions where
it is best adapted are outlined on the map in Figure 24. It is a
warm season crop that makes its entire growth during the warm months
of the year. Three species are generally recognized as being of
agricultural value. They are: Lespedeza striata, the common
lespedeza; Lespedeza stipulacea, the Korean lespedeza; and Lespedeza
sericea, the relatively recently developed perennial lespedeza.53

Climatic and Soil Factors for Common Lespedeza. Common
lespedeza is late maturing and is grown almost exclusively in regions
with a hot climate such as that south of the Ohio River. It is
found growing on all the principal soil types of the South, thriving

52. Ibid, pp. 8 - 9.
Figure 24. Approximate northern and western range of annual lespedezas.

- Farthest point at which common lespedezas has volunteered at least two years.
- Farthest point at which Korean lespedezas has volunteered at least two years.
- Northern and western limit of common lespedezas for agricultural uses.
- Boundary of region in which Korean lespedezas is of greatest use.

Source: Picters, A.J., *The Little Book of Lespedezas*, Figure 2, P. 18.
on soils ranging from the poor red-clay soils and the sandy soils of the Costal Plain to the rich alluvial soils of the Mississippi River Delta. It seldom makes more than five or six inches of growth on the former, but the latter, because of their high fertility, will produce enough growth to furnish a good hay crop. Although it will thrive on soils that are practically devoid of humus, an increased humus content and a liberal amount of phosphorus are needed if the crop is to be used for hay. An abundance of moisture is required for maximum growth, but the soil should be well drained. The crop will not succeed on wet land. A soil containing a good quantity of lime will produce a better lespedeza crop, but it will grow on soils too acid for alfalfa or red clover. Its lime requirement, according to Truog, is low.

**Economic Factors of Common Lespedeza.** Common lespedeza has been used principally as a pasture crop in the past, but its use as a hay crop is increasing especially on the soils that were once fertile but that were cropped too heavily to permit their use for the higher yielding legumes. The hay is of excellent quality and sells for a good price. Its greatest value is that as a forage crop; it is considered the best summer legume pasture crop for poor soils which has been introduced into the South, because some growth is made even on sandy and gravelly hillsides as well as upon heavy clay soils. A good growth of the crop will be made indefinitely in permanent pastures if it is not grazed too heavily in the late summer when it should be reseeding itself. The best summer pastures of the South are

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a mixture of lespedeza and Bermuda grass on the heavier soils and lespedeza and carpet grass on the sandy soils. The crop is a good soil-improving crop in that it improves the nitrogen and humus content of the soil. It is being used more and more extensively as a rotation crop in the South. Its place, therefore, is that of a rotation legume on soils too poor to produce other legumes profitably and that of a crop to increase the value of old, poor permanent pastures.

**Korean Lespedeza.** Korean lespedeza matures earlier than the common varieties, consequently it can be grown farther north than the others. (See Figure 24). Korean is said to be more drought resistant than other lespedezas in some sections; in other sections, the Kobe variety of the common lespedeza is reported as more drought resistant. Korean lespedeza is not suited for the extreme South and should not be used south of Tennessee except in the Piedmont of Georgia and South Carolina.

The advantage of Korean lespedeza, like that of the common varieties, lies in its ability to grow where other clovers fail. It grows on thin acid soils during the hot, dry months when most other forage crops are languishing. It normally makes a larger growth than the common varieties and yields from one to three tons of hay per acre from good stands on good soils. Its value as a cash crop depends almost entirely upon the supply and demand for seed. It will withstand severe trampling and pulling, and even under heavy grazing conditions it will produce seed. The washing on badly eroding fields can

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be retarded by using *Lespedeza*.

**Lespedeza Sericea.** *Lespedeza sericea*, the perennial which was recently added to the family of *Lespedeza* of agricultural importance, is still in the experimental stages. Much is still to be learned relative to its adaptations and uses. It will grow in any climate with long enough a growing season and a high enough mean temperature for corn. If it is provided with a mulch or protection through the first winter, it will probably withstand the winters as far north as the Great Lake Region and at least to the center of the Corn Belt.

*Lespedeza sericea* is suited to a comparatively wide range of soils producing good yields on soils much too low in fertility for red clover. Of course on average soils, the better the land in natural fertility the better the *sericea*. *Sericea* that is growing on heavy soils with a hard pan near the surface does not heave badly during the winter months even under conditions which cause severe heaving in alfalfa, sweet clover, and red clover. The crop is extremely drought resistant as a result of its deep and extensive root system; it is fully as resistant as Korean *Lespedeza* and probably more resistant than sweet clover, red clover, or alfalfa. It has survived winters with temperatures of 15 degrees below zero Fahrenheit with little or no snow for protection. A good stand of *sericea* should last indefinitely, outliving an alfalfa stand on good land and under good management.

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59. Ogden, H. P., Personal Interview
It is too much to expect large crops of sericea on very poor land, but it probably will do better there than anything else if allowed to grow undisturbed for a couple of years. Apparently, it can be grown to advantage on soils too poor to produce a profitable corn crop. It appears better suited to the heavier loams although it makes an excellent growth on various kinds of soils. Time is not an essential requirement to getting and maintaining a good stand, but it frequently gives a material increase in yields. Both the thick growth and the winter coating of fallen leaves which the soil receives prevent erosion. The crop is not a fire hazard if left uncut, because ignition is difficult even in the driest of fall weather.

The exact value of sericea is still rather uncertain. The hay seems to be lacking in palatability especially to dairy cows. At the present time, insufficient investigation has been done with regard to this fault. Some people claim that the apparent unpalatability is overemphasized; others think that excellent results can be secured by mixing sericea with other varieties of hay; and still others are of the opinion that this factor is of great enough strength to exclude it entirely from the farm program. Sericea is a poor land substitute for alfalfa, and until more is known concerning its palatability, it should not replace alfalfa except when the possibilities of getting an alfalfa stand are absolutely doubtful.

X. Vetches.

Common Vetch.  Common vetch, one of the two varieties of vetch usually grown in the United States, is strictly an annual. It is largely grown as a winter crop with oats or wheat for hay and either alone or with oats for seed in the western parts of Oregon and Washington, as a winter green-manure crop in the citrus districts of southern California, and as a winter crop, usually with oats, rye, or barley in the Southern States. Figure 25 shows where it is grown in the United States.

Figure 25. Regions suited to the fall seeding of common vetch. Source: Piper, C. V., McKee, Roland, and Hillman, F. H., Vetches. U. S. D. A. Farmers' Bulletin No. 515, Figure 1, p. 2.

Climatic and Soil Factors. Common vetch, when used as a spring-sown crop, succeeds only where the summers are fairly cool; hot, humid weather is injurious to it. The winter strain ordinarily is but little injured by temperatures of ten degrees, but zero weather causes much

winterkilling. It does not thrive on poorly drained land. Best results are secured on loams or sandy loams, but good crops can be grown both on sandy and gravelly soils. It is a good soil improver for poor soils. Thorough inoculation is necessary on poor soils as without it failures commonly result.63

Economic Factors. Vetch, like many of the other legumes, is valuable for a variety of uses such as hay, pasture, soiling crop, silage, green manure, and seed. In some localities such as Oregon, it is a common practice to broadcast vetch seed in a small grain stubble. Good results are secured when the grain is spring sown and when the vetch is sown quite early in the fall. Otherwise, the ground is so compact that a well prepared seed bed is necessary. Special preparation of the seed bed is usually necessary in the South. Very few successes have been noted thus far from attempted seedings in cotton or other intertilled crops. This method has given excellent results where the soil is thoroughly inoculated.64

Vetch is usually grown after spring-sown oats in Oregon and Washington; it is used also as the legume crop in rotations with potatoes or corn. It is mostly grown with Johnson grass in the Southern States especially where the grass volunteers. Vetch can be mixed with a fall seeding of small grain, thus providing a hay crop that can be harvested about the middle of May. The Johnson grass which follows, along with other volunteer grasses, will often yield two more cuttings of hay. The lateness of the harvesting of vetch in the spring

64. Ibid, p. 2.
seriously interferes with the cotton crop which may follow immediately. The inclination of vetch to persist when once grown, especially where the winters are mild, oftentimes makes it quite objectionable. It should be followed immediately by an intertilled crop if it is to be held in check. 65

**Hairy Vetch.** Hairy vetch, also known as sand vetch, agriculturally differs from common vetch in being much more hardy and in acting as a biennial if planted in the spring. It succeeds well wherever common vetch does and can be grown much farther northward, withstanding well the winters of eastern Washington, Michigan, New York, and parts of New England. The crop does especially well on sandy soils, but it can be grown on any well-drained land. It is more drought resistant than common vetch, often making a good crop under dry conditions where the latter fails. It will germinate and grow in soils too alkaline for most legumes. 66

Hairy vetch has succeeded in nearly every state of the Union, but its importance probably will be limited to those regions where alfalfa and red clover do not succeed or do not meet the requirements of a short rotation that may be desired. It is adapted to nearly as wide a range of uses as red clover, and it is the best substitute for the crop where red clover does not succeed. The hay is of excellent quality, but it is difficult to mow and handle. When planted in the spring, it makes a large amount of grazing the first year and a full hay crop the next.

Hairy vetch gives satisfaction as a winter cover crop if sown early in the fall; it is the best winter green-manure and cover crop

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for the tobacco fields in the Connecticut Valley. Where neither red
clover nor crimson clover succeed, it is the best crop for this pur-
pose, especially on sandy soils. It will germinate under much more
unfavorable conditions than crimson clover. Its use in the South
parallels that of common vetch. When once established, the plant is
inclined to persist. This is a bad fault, especially where wheat
makes a part of the rotation, because the seeds of the two plants can
be separated with only great difficulty.

XI. Soy Bean.

The soy bean, an Asiatic legume introduced into the United States
as early as 1804, was regarded more as a botanical curiosity than as
an agricultural plant of economic importance until 1890. Since that
time it has assumed great importance largely because of the introduc-
tion from Asiatic countries of varieties suited to the wide range of
soil and climatic conditions in the United States. It has been used
mainly for forage purposes in the United States, but the greater
utilization of the soy bean and its by-products for industrial purposes
will undoubtedly result in a vast increase of acreage. The soy beans
crushed for oil increased from 2,230,000 pounds in 1923 - 24 to
72,632,000 pounds in 1932 - 33. Figure 26 shows the chief production
regions. Areas 2 and 3 contain the leading states in both acreage and
seed production.

67. Ibid, pp. 9 - 12.
68. Morse, W. J., Soy Beans: Culture and Variety, U. S. D. A. Farmers'
Bulletin No. 1530, pp. 1 - 3.
Figure 26. Areas of the United States in which the soybean is especially adapted. Outside the numbered areas the soybean either cannot be grown profitably or it is in the experimental stage.

Source: Morse, W.J., Soybeans: Culture and Varieties, U.S.D.A. Farmers Bulletin 1520, Figure 2, p.5.
Climatic Factors. The soy bean has about the same climatic adaptations as corn. The crop is especially well adapted to the northern half of the Cotton Belt and the southern part of the Corn Belt. This is because the larger and later varieties, which give yields that make their extensive cultivation economical, can be grown. Early varieties give fair yields of seed and later varieties can be grown successfully for forage purposes in the Northern States. A seed crop seldom develops normally in the southermost part of the Gulf States, but an excellent growth of forage can be produced. Extremely hot weather during the period when the seed is forming, such as that of the Gulf States and that of parts of California, Arizona, and New Mexico, prevents a normal development of the seed. After the plant is well started, it will withstand short periods of drought; a wet season neither seriously retards growth nor decreases the yield. A prolonged drought or excess moisture during the germination period are likely to cause severe injury to the stand. A light frost has but little effect upon the plants when they are young or when they are nearly mature; it is less susceptible to such injury than corn, field peas, or cowpeas.

Soils. The soy bean, although it will succeed on nearly all types of soil, does best on mellow, fertile loams or sandy loams. In general, its soil requirements are about the same as those of corn, but usually it will make a more satisfactory growth than corn on poor soils if properly inoculated. Cowpeas, on the other hand, do better than soy

70. Morse, W. J., op. cit., pp. 3-4.
beans on the poor soils. Better results are to be expected from soy beans than from red clover or alfalfa on soils lacking in fertility or on acid soils, but if the crop is to do its best, a fertile soil containing an ample supply of lime is necessary. Good results can be expected from sandy soils such as those of the Coastal Plain if proper inoculation and moderate applications of fertilizers are made. Although a well-drained soil is not required, soy beans do not do well where water stands on the surface for any considerable length of time. Drained swamp lands, provided the acidity, if present, is corrected by the use of lime, and some muck soils give excellent soy bean yields.

Economic Factors. Soy beans can serve as either a grain crop or a hay crop in many cropping systems. Its place in the rotation will depend upon the competing crops and upon the purpose for which the crop is grown.

A large acreage of soy beans is grown primarily for hay, but it is an expensive hay crop and should not be used as such unless there is no better forage crop available. Seed is usually expensive, a well prepared seed bed is essential, and considerable intertilling is necessary to control weeds. Other forage crops, such as lespedeza on the poor lands and the clovers or alfalfa on the more fertile soils, will give a much cheaper hay. Much less work is necessary to get a crop of lespedeza or clover sown; several crops of hay can be secured from one seeding of alfalfa and also from lespedeza if it is permitted to reseed itself.

71. Ibid, p. 4.
The exact cost of production of a ton of hay on a group of Illinois farms that kept detailed cost records was $10.56 for soy beans, $6.93 for clover, and $5.77 for alfalfa in 1933. Furthermore, the quality of hay is usually in favor of the clovers, because soy bean hay often tends to be weedy, coarse, and woody. Seed bed preparation, cultivation, and harvesting come so as to interfere severely with the major intertilled crops such as corn and cotton; the soy bean is a competitor for labor, power, and equipment.

Situations which merit the use of the soy bean as a hay crop are:

(1) when the clover or other hay crop winterkills or there is a failure to get a stand, the soy bean makes a good emergency catch crop thus providing a legume hay and permitting the rotation to complete its circuit without undue interruption; (2) when the soy bean as a grain crop is one of the major crops of the rotation, the necessary hay may be secured from this crop without making necessary a separate hay crop; and (3) when the rotation is being changed or when the perennial hay crop is being renewed, the soy bean furnishes a temporary annual hay crop that can be readily worked into the existing situation.

The production areas of soy bean hay are not greatly influenced by markets and transportation. Most of the crop is consumed on or near the farm where it was produced. It cannot be an important competitor for the hay markets of the country until a better quality of hay is

produced and until its cost of production is brought more nearly in line with that of alfalfa and clover.

The Soy Bean as a Grain Crop. The soy bean is of great importance as a grain crop. Future expansion will depend upon an increased development of the uses of the oil and the meal. The crop has no definite place in the standard rotations at the present time. Many Corn Belt farmers have attempted to substitute soy beans for oats, but this is not a satisfactory place because the crop cannot serve as a nurse or intermediate crop between the intertilled crop and the legume forage or green manure crop and because it is competitive rather than supplementary with regard to labor and power. It might be substituted for the legume soil improvement crop; yet in spite of the fact that it is a legume it is not a good soil improvement substitute for the clovers. The soy bean root system is shallow as compared with the red or sweet clover, consequently the mineral elements are removed from approximately the same part of the soil as that of corn or cotton. It is true that the major part of the nitrogen used by the crop may come from the air, but if all the grain is sold and if the straw is subjected to careless leaching, the fact that the crop is a legume does not mean necessarily that the available nitrogen of the soil will be materially increased.

The third and most logical place for the soy bean in the rotation is that as an intertilled cash crop. The labor and power requirements, the growing season, and the marketable product are comparable. When the yields are large enough and the price is high enough to give per acre returns equivalent to those received from such crops as corn, cotton, or tobacco, the soy bean will be able to
compete with these crops. Because the soy bean is a legume, it may be used to give a higher percentage of the rotation land in the inter-tiled cash crops even when the other crops may be more profitable. Perhaps two years of corn would be too great a proportion of the land in corn to maintain its fertility, yet one year might be insufficient to give the farm the maximum returns of which it is capable of producing. One year of corn followed by one of soy beans might give the proper balance to the rotation. Little soil preparation is necessary to prepare a small grain seed bed after soy beans, but to counter-balance this favorable factor is the fact that soy beans leave the land unduly exposed to erosion.

Some discrimination can be held against soy beans as an inter-tiled crop because of the difficulty of keeping weeds under control. The long growing period permits most weeds to go to seed before the crop is harvested. It is almost impossible to eradicate the weeds from the growing crop.

Economical soy bean production demands conditions conducive to extensive farming. Large, level fields not only reduce the costs of seed bed preparation and cultivation, but they aid greatly in lowering the harvesting costs. Less loss from shattering and a pronounced reduction of harvesting costs have made the use of a combine-harvester an almost essential practice if soy beans are to be produced in competition with other crops. Such large machines are unsatisfactory in small, irregular fields.

Transportation costs are of importance in connection with soy bean grain producing areas. The value per unit weight is normally higher than that of corn or oats, but the product is still bulky enough to
make it necessary to consider transportation costs. Those areas nearer the consuming centers will have prior claim on the market.

Other Uses. Soy beans have been used as a green-manure crop, but there are other crops just as good if not better that are considerably cheaper. If the soil is sweet enough for sweet clover culture, it will be cheapest and the best green-manure that can be used. Truog states that soy beans have a medium lime requirement, consequently, if the soil is sour, some legume such as alsike clover, crimson clover, or lespedeza will give much better results.

Highly satisfactory results can be secured by growing soy beans in combination with other crops such as corn, the sorghums, Johnson grass, Sudan grass, or cowpeas. A better balanced feed and the fact that the yields are often somewhat better than when the crops are grown separately merit the use of soy beans in mixtures. Experimental evidence and general observations indicate, however, that a mixture of corn and soy beans results in a reduction in the yield of corn, but the yield of corn is partly offset by the yield of soy beans. The soy bean has a valuable place mixed with corn in areas subject to severe chinch bug attacks. One or two plants in each hill of corn will create sufficient shade to materially reduce the corn losses from this insect.

Biological Factors. The soy bean is comparatively free from damage caused by insect pests and diseases in this country. Grasshoppers do considerable damage in the drier regions, but they can be easily controlled by using poison-bran bait. Blister beetles have become so

73. Truog, Emil, op. cit., p. 21.
74. Morse, W. J., op. cit., pp. 22 - 23.
Injurious to soy beans in some of the Southern and Western States as to cause considerable alarm. Flea beetles are especially numerous in the Gulf States where they frequently do considerable damage to soy bean crops. The green clover worm sometimes does considerable damage to soy beans along the South Atlantic Coastal Plain. Other insects attacking the crop are not centered in any particular part of the country. The fungus and bacterial diseases are somewhat more prevalent in the warm, moist sections of the United States. Woodchucks have done damage to soy beans in small areas of the Northern States. Rabbits often cause the failure of a soy bean crop in parts of the Great Plains and the Gulf Coast.

XII. Cowpeas.

The cowpea, a native bean of central Africa, at present is the best known and most extensively grown leguminous crop in the Southern States, but it can be grown in many of the Northern States. Figure 27 shows the comparative distribution of the crop in the United States.

Climatic Factors. The greatest value of the cowpea is attained in the Southern States; it gradually lessens as one moves northward, largely because it is a warm weather plant. It has about the same climatic requirements as corn, but more heat is generally required. Under very dry conditions, it will produce only a moderate amount of forage and a very small number of seeds if any, but a considerable degree of drought can be withstood. The least touch of frost, both in

75. Ibid, pp. 25 - 35.
Figure 27. Comparative distribution of cowpeas in the United States. 
Area 1, area in which they are grown most extensively; 
Area 2, area in which they are grown quite generally; 
Area 3, area in which they are grown to some extent. 
Source: Morse, W. J., Cowpeas: Culture and Varieties, 
U. S. D. A. Farmers' Bulletin No. 1145, Figure 2, p. 8.

spring and in fall, will injure the leaves, and a heavy frost will 
kill the plant. The cowpea will withstand moderate shade sufficiently 
well to be valuable in orchards, yet heavy shade causes considerable 
mildew attack.

Soils. Cowpeas will succeed on practically all types of soil, 
doing apparently quite as well on sandy soils as on heavy clays. It 
will do better than alfalfa or clover on thin soils or soils that are 
deficient in lime. The cowpea can be grown more successfully than any 
other legume on a greater variety of soils under adverse conditions. 
A small growth of vine, but a generally good proportion of seed, is 
yielded on poor soils; very rich soils give an abundant vine growth 
but a very small yield of grain. Clay soils do not yield well the 
first year, but they do much better the second season. Generally

77. Ibid, p. 2.
speaking, cowpeas do best on good cornland, but they will thrive on all types of soils that are well drained, properly inoculated, and moderately rich. 78

The cowpea has a low lime requirement according to the Truog rating. 79

Economic Factors. Cowpeas are usually used for forage and for green-manure purposes similar to the corresponding uses of the soy bean. There has been very little use of the grain for commercial purposes, consequently, it is of little importance as a cash grain crop at the present time.

A mixture of corn and cowpeas makes an excellent silage crop; cowpeas are being used extensively for this purpose on many dairy farms, especially in the northern part of the cowpea area. Such a mixture also can be pastured or part of the ears of corn can be removed and the crop cut for hay. The sorghums are more generally used along with cowpeas for hay, but other crops such as Sudan grass, Johnson grass, soy beans, and millet often are sown with it in mixtures. 80

Since the crop is grown primarily as a forage crop to be consumed on or near where it is produced, the choice of production areas are not greatly influenced by transportation and markets. It must compete with many of the other legumes for a place in the cropping system. Quite often the clovers and alfalfa will give greater returns more cheaply if they can be grown.

78. Ibid, p. 2.
79. Truog, Emil, p. 21, op. cit.
Biological Factors. Root-knot and wilt, the most serious diseases of the cowpea in the United States, are most generally found in the sandy soils of the Southern States. They rarely become serious on the heavier soils. Insect damage is seldom serious, except that several species of weevils attack the seed of cowpeas. Their damage does not seem to be localised.

XIII. Peanuts.

The peanut, a pea rather than a nut, is an important money crop in no less than nine of the Southern States. The possible area adapted to the production of peanuts in the United States is shown in Figure 28.

Figure 28. Possible area of peanut production in the United States. Source: Beattie, W. R. and Beattie, J. H., Peanut Growing, U. S. D. A. Farmers' Bulletin No. 1856, Figure 1, p. 3.

81. Ibid, pp. 15 - 16.
Climate. Peanuts will adapt themselves to a wider range of climate than almost any other southern crop provided the soil conditions are favorable. A growing season of 100 to 140 days without frost, a moderate rainfall during the growing period, an abundance of sunshine, and a relatively high temperature are the general climatic requirements of peanuts. A normal annual rainfall of from 42 to 54 inches gives the best results; yet fair yields have been made where the annual rainfall is less than 19 inches, and good crops have been produced on low bottom lands with 54 to 60 inches of rainfall. 82

Soils. Peanuts produced for the market do best on light, sandy loam soils. Poorly drained or sour soils do not give good results. The crop may be grown on almost any type of soil except the black waxy and extremely heavy clays when it is produced for hog feeding or as a forage crop. Sandy loam soils have a loose surface that does not hinder with the pod development after pollination, and such soils that produce good crops of beans and potatoes are considered suitable for peanuts. 83

Soils having sufficient lime usually give a peanut crop that is better filled, that has whiter shells, and that has a greater weight per bushel. Various investigators report that results obtained from the use of lime on peanuts indicate that the quality of the peanuts is affected much more than the quantity. 84

Peanuts do not improve the soil as ordinarily handled in spite of the fact that they are a leguminous crop capable of collecting the

84. Ibid, p. 5.
free nitrogen of the atmosphere and storing it in nodules upon their roots. Other legumes, such as the clovers, cowpeas, velvetbeans, soy beans, and alfalfa the root systems of which are not removed from the soil, are much better soil improvers. 85

Economic Factors. The preparation of the peanut and its products for the retail market makes necessary peanut cleaning factories and oil mills. This work cannot be done to advantage on the farm, because the many and varied uses developed for peanuts require intricate and expensive machinery. 86 The necessity of such facilities often excludes the production of peanuts in areas physically suited to their culture.

Every part of the plant and all by-products resulting from the factory processes through which peanuts pass can be utilized to good advantage mainly for stock feeding. The hay, press cake, hulls, inferior kernals, germs, and red skins need not be wasted if there is available any livestock to which these products can be fed profitably. The vines from which the pods have been removed now have considerable market value as hay. It cannot compete with the other legume hays of a higher protein content such as alfalfa, clover, cowpea, and soy bean hay, but when it is available, it may be used where a legume hay is desired. Moldy peanut hay is unfit for feeding purposes, and care must be used in feeding good peanut hay to horses and mules because of the dirt and dust that it usually contains. Light and inferior peanuts, removed in recleaning and grading, may be fed whole to hogs, or they

85. Ibid, p. 5.
86. Ibid, p. 25.
may be ground and mixed with other feeds for dairy, poultry, or hog feed. Peanut cake and meal have become important since the establishment of the peanut oil industry in the Southern States. Peanut meal causes neither a soft pork nor an off-flavored milk.87

Biological Factors. The peanut in the United States is relatively free from injury during growth by diseases and insects. Leaf spot and root rot cause appreciable losses.88 They seem to have no specific territorial location.

XIV. Velvet Bean.

Climatic Factors. The velvet bean is a warm weather legume produced almost exclusively in the Coastal and the South Atlantic States. Figure 29 shows the approximate distribution of the crop in the United States. There is a considerable difference between the areas suited to early, medium, and late varieties. Figure 30 shows the approximate northern limit of each.

Soils. The velvet bean is especially well adapted to the well-drained portions of the Atlantic and Gulf Coastal Plain areas. It has been found that velvet beans will produce more vegetable matter on cut-over pineland and on sandy soils than any other annual legume grown at the present time. It is used extensively as a green-manure crop in such areas. This plant also makes a good growth on the clay soils in the northern portion of the Cotton Belt, but it is questionable whether they will do better than cowpeas on the poorer soils in

Figure 29. Approximate distribution of velvet beans in the United States. Source: Piper, C. V. and Morse, W. J., The Velvet Bean, U. S. D. A. Farmers' Bulletin No. 1276, Figure 10, p. 11.

Figure 30. Average dates of the last killing frost in the spring and the first killing frost in the fall. The three sets of lines represent the approximate northern limit of the late, medium-early, and early maturing varieties of velvet beans. Source: Piper, C. V. and Morse, W. J., The Velvet Bean, U. S. D. A. Farmers' Bulletin No. 1276, Figure 12, p. 13.
this area. The crop does not do well on cold, wet soils and should never be planted on other than warm soils.  

**Economic Factors.** Velvet beans may be utilized as a winter pasture, a green-manure, for silage, and for hay. It is unexcelled as an annual green-manure crop. Its value as a feed for stock is becoming to be recognized in the South. Many of the beans are fed ground in the pod, but the value of the crop as a winter pasture, either for carrying cattle through the winter or for fattening them, is now well established. This latter practice eliminates the cost of gathering and grinding the beans; feeding experiments indicate that very little of the actual feeding value of the plant is lost in this method. Velvet bean vines become so long and tangled that it is very difficult to handle them when cut for hay, consequently they are seldom used for hay. Late maturing varieties planted without a supporting crop produce such a dense growth of vines that they will smother out weeds, persistent grasses, and tree sprouts. A very good quality of silage can be made from corn and velvet beans planted together. The most important use of the crop is as a grazing crop for cattle and hogs in the autumn and winter, but horses and mules do not do well on it.

**Biological Factors.** The velvet bean caterpillar is the only insect which causes serious damage to the crop. It seldom appears farther north than southern Georgia.

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90. Ibid, pp. 16 – 18.
91. Ibid, p. 27.
XV. **Field Pea.**

The field pea, an annual true pea often called the "Canadian field pea," is of considerable importance in the United States. Figure 31 shows the areas where the crop is well adapted.

![Map of the United States with areas shaded to indicate the areas where the field pea is well adapted.]

**Figure 31.** Areas of the United States to which the field pea is well adapted. Source: Vinall, H. N., *The Field Pea as a Forage Crop*, U. S. D. A. Farmers' Bulletin No. 690, Figure 8, p. 6.

**Climatic Factors.** A cool growing season is essential for the best results with the field pea, because high temperatures are much more injurious than frosts. The only period when frosts are disastrous to the crop is when they occur just at the period when the pods are setting. Such climatic requirements limit the successful production of the field pea as a summer crop to the Northern States and Canada and to high altitudes of the mountainous areas of the west. It may be grown as a winter crop in the Southern States. The moisture requirements are less exacting than those of temperature, but, other things being equal, the crop does best in regions of fairly abundant rainfall. A good crop can be produced in western Canada in
regions with a 15 inch rainfall, but farther south in Kansas, Nebraska, or Colorado, a rainfall of 20 inches is inadequate.

Soils. Clay loams of limestone formation are best suited to field pea culture. It thrives best on a calcareous soil, and when the soil is not of limestone formation, frequent lime applications will be advantageous. Sandy loams give fair results, but on light sands the crop usually produces a small growth and it suffers quickly in periods of drought. A heavy growth of vines but comparatively few pods are produced on heavy, black soils rich in humus. The field pea demands good drainage if it is to be a success. It will grow well on moist soils but will not succeed in locations where standing water occurs or where the soil is habitually soggy. Alkali soils are disastrous.

Economic Factors. The field pea crop is commonly harvested in some localities by pasturing with hogs or sheep. Very rapid gains can be made by combining the pea pasture with a dry feed. Many farmers thrash the peas and feed them along with some cereal grain with good results. Some of the peas go to canning factories when they are available and pay enough. The crop is often used as a hay crop in Pennsylvania and New York and the Southern States. Pea straw is sufficiently high in protein to be of value as a feed. The crop is utilised sometimes by combining it with some small grain for a silage. The expense of the seed has prohibited to a large extent the use of field peas as a winter cover crop.

93. Ibid, pp. 5 - 6.
Biological Factors. Powdery mildew reduces the yield of field peas considerably in the humid climates. Leaf spot is quite troublesome in the pea-canning districts of Wisconsin and Ohio. The most serious insect enemy of the field pea is the pea weevil. It has done more than anything else to limit the production of this crop in Canada. The pea moth has become quite troublesome in the pea-growing districts in northeastern Wisconsin and occasionally in Michigan. 95

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CHAPTER IV.

NON-LEGUME FORAGE CROPS.

I. Timothy.

Climatic Adaptations. Timothy, by far the most important hay grass in the United States, is a hardy perennial that is distinctly a cool climate grass. It does not succeed well in the United States south of latitude 36 degrees excepting where the altitude is sufficiently high to provide cool weather. Timothy thrives fairly well on the Alaskan Coast, but the winter cold and the summer drought of the interior are too severe for the plant. It has been known to withstand the winters and to mature seed in parts of Alaska when redtop, tall oat-grass, orchard grass, and velvet grass were completely killed. Although no definite data regarding the minimum cold that timothy will withstand have been recorded, it is evident that the plant is more cold resistant than most cultivated grasses.

Timothy will not withstand the hot, humid summers such as those found in the cotton regions. It is not resistant to droughts. Besides the natural unadaptability of the crop to warm climates, crab grass and other summer weeds are destructive competitors in the Cotton Belt. Only one cutting of hay normally can be made from a seeding in the Cotton Belt, but even this degree of success can be obtained in the Gulf States only on the richest lands.

1. Piper, C. V., Forage Plants and Their Culture, p. 143.
2. Ibid, p. 144.
Figure 17 shows that the most extensive acreage of timothy is in and immediately north of the Corn Belt.

**Soil Requirements.** Timothy is best adapted to clay or loam soils that are fairly retentive of moisture. Because it does not possess much drought resistance, it does best where the moisture is abundant. Sandy soils give poor results. A fertile soil will give better returns than a poor one as is shown by the greatly increased yields that result from the use of large quantities of stable manure, the plowing under of a leguminous crop, or the application of nitrogenous fertilizers.

**Economic Factors.** Timothy is raised chiefly for hay because of the ease with which it can be cut and cured, the certainty of securing a stand, the low seed cost per acre, the good yields of hay per acre, the relative lateness of harvest, and the longer period in which it may be harvested. In spite of the fact that other hays, especially the legumes, normally yield a greater amount of digestible nutrients per acre, it may happen that one or more of the above factors are of enough importance in a region to encourage timothy production there.

Large quantities of timothy hay were formerly consumed by horses both in the cities and on the farms, but this market has practically disappeared with the greatly diminished number of horses. Other types of livestock, such as dairy cattle, may have increased enough to absorb the hay surpluses created by the reduced number of horses, but dairy cattle demand a hay with a higher protein content.

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than timothy. This increased demand for hay has been met by an increased use of legumes or of non legumes with a higher digestible protein content than timothy.

Formerly, the regions close to the large cities had an advantage in so far as the timothy hay market was concerned. Transportation costs are an important factor with a bulky product such as hay, and as large quantities of the marketed timothy hay went to the city horse owners, the regions close by had an economic advantage over the areas farther away. The automobile and the truck have almost completely replaced the city horse, consequently, population centers and transportation no longer have a great influence on the production areas of the crop.

The reduced number of horses on the farm has resulted in a large reduction of timothy hay grown to be fed on the farm where it is produced. The farmer normally has a supply of straw or other crop residue that will make practically as good a roughage for horses as timothy hay. He will utilize this rather than have to bother with a hay crop. Still other farmers have a legume crop from which they can harvest enough hay for their horses, thus necessitating no additional hay fields.

Timothy for Pasture. Timothy forms an important element in most mixtures used for temporary pastures. It alone is not well adapted to permanent pastures because most of it will disappear in about three years after seeding. Hay meadows may be pastured in the fall with no danger of serious harm to the next hay crop nor to the stand, but
spring pasturing injures the following hay crop enough so as to be unprofitable. 4

There is little economic justification for the use of timothy as a temporary pasture because other forage crops have as high or a higher carrying capacity; legumes are especially more desirable not only from this standpoint but also because of their soil improvement capacities and because of their value as a high protein pasture. Timothy seed makes, however, a very economical filler for pasture seed mixtures to insure some crop on the spots where the main part of the mixture may fail. A legume pasture containing some timothy also has more variety of feed for the animals. It also will provide pasture for some time after the biennial clovers have matured.

The economic position of timothy is not very promising. It is primarily a hay crop but other hays are better, even for horses. 5 Its secondary use as a pasture crop is perhaps a little better because of its value in mixtures, but even here other combinations may prove more valuable as plant breeding work progresses and as the seeds of better crops become more plentiful and cheaper. Farmers have favored timothy because its harvesting interferes less with their other crops, but if other crops such as alfalfa can be grown at a greater profit in spite of the interference of labor demands they will replace the timothy.

Biological Factors. Various insects, including grasshoppers,

5. Ibid, p. 163.
bill-bugs, joint-worms, wire-worms, and chinoh bugs, attack timothy quite severely. They are not specifically prevalent in any one area, but are common throughout the timothy regions. White grubs, wire-worms, and bill-bugs are harbored in timothy fields. Old timothy meadows are especially bad as insect harbors. If the succeeding crop is corn, these insects may attack it quite severely. The leaf-miner, capsid bug, and timothy stem-borer cause damage in special localities.6

Timothy is susceptible to very few fungous diseases. Timothy rust is found in nearly all states east of the Mississippi River and in Minnesota and Iowa. Leaf smut sometimes attacks timothy in rather widespread areas. It has been specifically reported as damaging to the crop in Wisconsin and Illinois.7

II. Kentucky Bluegrass.

Climatic Adaptations. Kentucky bluegrass, a native of Europe and Asia, is by far the most important pasture and lawn grass of the United States north of the Cotton Belt. It is adapted primarily to temperate regions of relatively high humidity, but it succeeds well under irrigation in the arid regions. The plant has a marked resistance to cold conditions, never freezing out in the most severe winters as far north as Alaska and Labrador. It languishes during the summer heat, however, and shows little vigor during the hot weather of July and August even with abundant moisture. As it survives hot summer weather and makes good pasturage in the fall and spring, the bluegrass area of usefulness extends farther south than that of timothy. The growth starts earlier in the spring than most other grasses, and it continues to grow as late into the fall as any other grass.

Soil Requirements. Well-drained loams or clay loams, particularly those that are rich in humus, are preferred by bluegrass. Southward, where it is especially abundant on limestone soils, it often grows to the exclusion of other plant species. The soils of the famous bluegrass regions of Kentucky and Virginia are of limestone origin. It is never abundant on poor soils but gives way to other grasses such as redtop and Canada bluegrass.

Spillman states that aside from the exceptions of the limestone areas farther south, bluegrass is confined rather strictly to the

8. Ibid., pp. 175 - 176.
9. Ibid., p. 176.
10. Spillman, W. J., Farm Grasses of the United States, p. 95.
glacial drift of the Northern States. This distribution is supposed to be caused by the presence of lime, magnesia, and, perhaps, potash in these soils. The climatic conditions are also more favorable to bluegrass in the glaciated area and it is not so particular in its choice of soils in the cooler regions as it is in the South where the long, hot summers are particularly unfavorable. It is decidedly shade loving in the extreme southern portion of its range.

The Truog rating of the lime requirement of Kentucky bluegrass is low.\(^1\) Formerly it was believed that bluegrass had a special liking for limestone soils, but recent investigations indicate that this preference is not primarily on account of the lime but because of the general richness of such soils. It is abundant on all good soils whether rich in lime or poor in that substance.\(^2\) Bluegrass is very sensitive to alkali.\(^3\)

**Affects of Drought.** Kentucky bluegrass has very little endurance to drought, but even in semi-arid regions, where it is normally burnt brown for at least two months, it promptly recovers with the fall rains. It will endure fairly wet soils but not so well as such crops as redtop or rough-stalked meadow grass.\(^4\)

**Value as a Permanent Pasture Grass.** Kentucky bluegrass is a more nearly perfect permanent pasture grass than any other known plant because of its palatability to all classes of livestock, the evenness of sod it forms, and its increasing productiveness with age. Fine horses and cattle attain their highest development in the Bluegrass.

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Region. It would be a perfect pasture grass in the regions with favorable soil and climatic conditions if it were not for, (1) its habit of remaining dormant during the dry, warm months of summer, (2) the length of time required to secure a good stand of it, and (3) its comparatively low yield of forage. Yet in spite of this formidable array of objections, much of the most productive land in the regions where the beef industry and horse raising are important is occupied by bluegrass pastures. These two industries are most highly developed in the sections where bluegrass is at its best, because good pastures are indispensable to the economical production of first-class beef and in raising horses on a large scale.

Under normal conditions, land that is comparatively level and that is fertile enough to be economically farmed will make greater returns if cultivated than it will as a permanent bluegrass pasture. The carrying capacity of a rotation pasture usually is as much as two or three times greater than that of bluegrass, and bluegrass yields as hay are insufficient for its use that way. Another advantage in favor of rotation pastures is the longer season of pasturage. It is true that bluegrass is slightly earlier than some pasture crops and that it lasts as long in the fall, but a good temporary pasture mixture will provide pasture for the full season, or at least for a large part of it, while bluegrass languishes during the summer. A combination of extremely early and extremely late crops in the temporary pasture seed mixture will give a full season of pasturage.

Bluegrass has no place in the average farm rotation because of the difficulty and the length of time necessary to get a good stand. A biennial crop that is a good soil improver, hay crop, and pasture crop is far more satisfactory in rotations. Tillable land will normally yield more in some cultivated crop than it will in pasture. Bluegrass, therefore, has little place on good, tillable farm land because of its low yields as a permanent pasture and because of its unadaptability to rotations.

Bluegrass is of an economic value to occupy land unfit for cultivated crops, providing the soil and climatic conditions are favorable to its production. Areas too rough and steep to be farmed, areas subject to erosion, small and irregularly shaped fields along streams, ridges, or other obstructions can be placed in bluegrass to an advantage.

The relative cheapness of land will greatly influence the choice of bluegrass production areas. If the land is cheap enough to permit it to be profitably handled as a bluegrass pasture, it may be so handled. Many cheap lands are too poor for bluegrass and must be avoided. The cheapness, therefore, must be the result of some economic factor, such as the unavailability of a profitable market for other crops, or the result of physiographic factors rendering impossible efficient cultivation of the land.

The acreage of bluegrass will decrease as farmers become aware of greater returns from the land in other crops. Many of them have large bluegrass pastures which would be plowed up if they knew more about rotations and legume crops. Many farmers, on the other hand,
are farming badly eroding and small, irregularly shaped fields that would make greater returns if placed in bluegrass. The mistake must not be made of farming a piece of land until it is too poor to make economical returns in the form of cultivated crops and then seeding it to bluegrass with the expectation of getting a good pasture.

Bluegrass has no equal as a lawn grass in the northern half of the United States, providing the soil is suitable and there is abundant water to keep it green during the summer. White clover mixes very well with it in lawn mixtures.

III. Canada Bluegrass.

Physical Factors. Canada bluegrass has climatic requirements quite similar to those of Kentucky bluegrass, but it is more resistant to summer heat and to drought. It is most abundant on poor soils, even on gravels and thin soils underlain by rock or clay; this is probably not because it has any special preference for such soils, but because of its inability to cope with other grasses on good soils. Canada bluegrass is often found on the sides of oaks where the subsoil is exposed, while other grasses occur on the good surface soils nearby. It is more drought-resistant than Kentucky bluegrass, but it is less well adapted to growing on moist or wet soils. It does not succeed well in the shade but is primarily a grass of the open. 16

17. Piper, C. V., Forage Plants and Their Culture, pp. 184 - 185.
Economic Factors. Canada bluegrass has a rather bad reputation because its seed was used to adulterate Kentucky bluegrass and because it has been compared with that grass. Canada bluegrass is primarily a permanent pasture grass with uses not unlike those of Kentucky bluegrass, but its main usefulness, however, is under conditions which Kentucky bluegrass will not endure; consequently, it is a substitute for rather than a competitor of Kentucky bluegrass. It will withstand very close grazing and, because its stems remain green, can be used as reserve pasturage late into the season. It is discriminated against by many people because of its wiry, bunchy nature. This seriously interferes with its use as a lawn grass.

IV. Bermuda Grass.

Bermuda grass, the most important pasture grass of the South, is successfully grown as far north as Maryland, Kansas, and the warmer valleys of Washington and Oregon. It has become more troublesome as a weed than valuable as a forage in Virginia and Maryland.

Climatic Adaptations. Bermuda grass is a warm weather plant; it requires warm weather during the growing season and can stand intense heat without injury. It cannot withstand the severe winters of the North. In general, it is best adapted in the United States to the same general area as cotton, where it is relatively as important as is Kentucky bluegrass farther north. It has become abundant in Arizona and California, but in these states it is more of a pest than a plant of economic value because of the difficulty it causes in

alfalfa fields. The slightest touch of frost will cause the leaves to
turn brown. 20

Soil Requirements. Bermuda grass makes its best growth on rich,
moist bottom lands, but they must be well drained. It will grow on all
types of soil common in the South. Because of its ability to grow on any
type of soil and its creeping character, Bermuda grass is an excellent
soil binder on sandy soils, on eroding slopes of clay, and in gullies.
It has been very useful as a cover on the levees of the Mississippi
River. The plant is not well adapted to shade, consequently it tends to
disappear in fields where it is densely shaded by other crops. 21

Economic Factors. Bermuda grass is used primarily as a pasture for
all types of livestock. Hogs, however, sometimes cause much damage to a
Bermuda grass pasture by rooting up the plants to get the root stocks.
It is usually sown in mixtures with other grasses, but it will crowd out
the other ones under favorable conditions and will be crowded out when
the opposite situation is true. The carrying capacity of Bermuda grass
pasture is good; it has been reported to be as high as three or four
animal units under favorable conditions, but on average soils about one
animal unit per acre is the normal carrying capacity. 22

An excellent grass hay can be made from Bermuda grass. The yields
are good under fair conditions. It is also an excellent lawn grass for
the South because it remains green during the summer even in dry

20. Piper, C. V., Forage Plants and Their Culture, op. cit., pp. 264 -
266.
weather, but the first severe frost in the fall causes it to turn brown.

The crop is not used in the normal rotations because it is rather persistent when it is once started. It is generally propagated by sod which is not adapted to rotation systems. Its place is that of a permanent pasture and hay crop or that of a lawn grass. It has a marked ability to withstand close grazing or close clipping which makes it well adapted for such uses.

V. Redtop.

Climatic Adaptations. Redtop, exceeded only by timothy, Kentucky bluegrass, and perhaps Bermuda grass as an important perennial grass in America, has probably a wider range of adaptation to climatic and soil conditions than any other cultivated grass. It succeeds well over most of the United States except the dry regions of the West and the hot regions of the extreme South. It withstands summer heat much better than timothy, and its resistance to cold is about equal to timothy.

Soil Requirements. Moist or wet soils are best for redtop. The crop will even grow vigorously in the bottom of shallow ponds where the leaf blades float on the surface of the water. It shows no marked preference for soil types provided moisture is abundant, but it does best on clay loams and loams. It will withstand considerable drought and on poor uplands, even if somewhat sandy, will thrive better than

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most other grasses. On the poor clayey soils such as those in southern Illinois, it succeeds better than any similar grass. Truog rates it as having a very low lime requirement.

**Economic Factors.** Redtop makes up much of the permanent pastures in the areas to which it is adapted, especially on wet and on non-calcareous soils. It is perhaps more suitable for pasture than it is for hay because of its characteristics, but unfortunately it is not a favorite with cattle as is shown by their usual preference to all other cultivated grasses over redtop in pasturing experiments.

The yields of hay on wet lands are usually greater than those of any other hay grass, but where timothy will grow it will return more than can be expected from redtop. Quite good results may be had by growing redtop in mixture, especially with timothy and alsike. Its qualities of making a fine, dense turf make it an excellent lawn grass, but under lawn conditions it is a short lived grass.

The mistake is often made of attempting to get timothy or Kentucky bluegrass to grow on land that has become too poor to produce cultivated crops. Both of these crops, especially the bluegrass, require a fairly fertile soil. Much better results could be expected if such lands were seeded to redtop.

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VI. Carpet Grass.

Climatic Adaptations. Carpet grass, a perennial creeping grass which forms a dense, close turf, is now widespread in the tropics of both North and South America. It is abundantly established on the Coastal Plain soils from southern Virginia to Texas, extending inland to Arkansas and northcentral Alabama. Abundant heat and moisture are required for its best development. When such conditions exist, it may be pastured from May to November or even longer farther South. It makes very little growth during the cool weather of winter. Growth is continuous throughout most of the year except when it is interrupted by severe droughts or by freezes. The leaves turn yellow with sharp frosts.

Soil Requirements. Carpet grass is especially adapted to sandy or sandy loam soils, particularly where the moisture is near the surface most of the year. It will occupy the land in practically pure growth on such soils, especially under heavy continuous grazing. On sandy lands in Florida and near the Gulf Coast, it is very aggressive, and wherever the land is closely pastured, it is the principal grass. It stands trampling and heavy pasturing without injury and seems to thrive best under such conditions.

Economic Factors. The economic position of carpet grass on the farm is that of a pasture grass. Its carrying capacity under favorable conditions is approximately the same as that of bluegrass, namely, about one head to two acres. It is more valuable than any other

perennial grass yet known for permanent pastures on much of the area in which it grows. One rarely finds carpet grass and Bermuda grass growing on the same area of soil, but lespedea and Dallis grass succeed well when mixed with carpet grass. Mixtures including bur clover and vetch (especially the Augusta or narrow-leaf variety) along with carpet grass are quite valuable. Once established they re-seed themselves each year. Carpet grass seed has been produced in commercial quantities in Mississippi since 1919.31

VII. Johnson Grass.

Climatic Adaptations. Johnson grass, a stout, erect, perennial grass, is rather abundant in the southern part of the United States from the Atlantic Coast west to central Texas in those states south of Tennessee. It is commonly a perennial as far north as the northern part of Kentucky and central Missouri, and has persisted as a weed in cultivated fields as far north as southern Iowa. It is also found in western Texas and in Arizona, New Mexico, and southern California chiefly in the irrigated districts. It extends along the Pacific Coast in the river valleys as far north as Oregon and Washington. The plant has become a nuisance, because of its aggressive underground stems, in the alluvial river bottoms and rich black prairie lands of the Gulf States. It is also classed as a dangerous weed on the irrigated lands of the Southwest where it grows luxuriantly along the irrigation canals.32

Soil Requirements. Johnson grass is primarily a rich-land crop. It will grow on all types of soil, but prefers rich land where there is an abundant supply of moisture. It is always found on the more fertile soils and only an indifferent growth is made on the uplands and poorer soils. On the latter, the problem of holding the plant in subjection is possible of solution, and other crops are being grown where it has obtained a foothold. It is expensive to attempt to grow cotton or other cultivated crops on the river bottoms and rich, black soils of the Cotton Belt, where Johnson grass thrives, on account of the labor required to keep these crops free from Johnson grass. Under such conditions it is often more profitable to utilize the grass for hay. 33

Economic Factors. Johnson grass can hardly be called a cultivated grass, for when it is once started it is difficult to eradicate. It is rarely sown intentionally, but where it is established it can be utilized for hay or pasture. Two crops and sometimes three of hay may be cut in one season on good soils. In fields heavily infested with the grass, a common plan is to plow the land in the fall and seed it to oats or oats and vetch. Two good crops of Johnson grass hay usually may be obtained the same season after the removal of the oat crop. It may be effectively used as an annual crop in the states north of Kentucky and Virginia. A large crop of hay may be secured from such a seeding. It is well adapted to seeding in mixtures with cowpeas. 34

33. Ibid, p. 3.
34. Piper, C. V., op. cit., p. 338.
The rootstocks of Johnson grass are well liked and are readily eaten by farm animals. They make good hog feed. Sometimes fields are plowed up in winter to furnish feed in this manner. Johnson grass has a good carrying capacity as a pasture. It may be eradicated by extremely heavy pasturing. Sometimes the formation of hydrocyanic acid may cause the death of cattle. There has been no report of such a case, however, in the South where Johnson Grass is most abundant. 35

VIII. Orchard Grass.

Orchard grass is grown to some extent in nearly every state in the United States and is quite common in the region east of the Mississippi River and north of Alabama and Georgia. Its greatest importance is attained in Kentucky, southern Indiana, Tennessee, North Carolina, Virginia, West Virginia, and Maryland. 36

Climatic Adaptations. Although orchard grass is strictly a temperate plant, it will withstand more heat for a longer season than will timothy, and it is also more easily injured by winter cold. It is grown more southward than northward because of competition with timothy and because of the fact that fall-sown stands winter-kill rather easily. Late frosts rather than winter cold are probably the cause of much of the winter-killing. It is susceptible to damage from late frosts largely because it begins its growth in spring much earlier than most grasses. 37

Soil Requirements. Orchard grass ordinarily does not succeed well on sands or muck, yet it will grow on practically all types of soil. Clays or clay loams give the best results. It prefers a moderate amount of moisture, and it is not particularly adverse to wet soils. Fair success can be attained when the rainfall is rather scanty because it is somewhat more resistant to drought than is timothy. Its great leafiness and its early growth before trees become leafy makes it well adapted to growing in shady places such as orchards.

Economic Factors. Orchard grass should be second or third in importance as a hay grass, because southward it is much better adapted than timothy and should be more generally employed, especially in mixtures. It will yield about as well as timothy when sown alone, but it should seldom be sown alone if it is grown for hay. Greater yields of hay will result from mixtures with tall oat-grass and alsike clover or with red clover. It is possible that good results could be attained from a mixture of lespedeza and orchard grass, because the latter will mature and can be harvested before the former makes much growth. Such a procedure would permit two hay crops from the same land. Orchard grass hay is fairly good feed for horses, but it is more valuable for cattle, especially for fattening them for market.

Orchard grass will be a valuable pasture constituent wherever it can be grown. Its ability to grow in cool weather allows it to furnish the earliest and the latest pasturage in the season. It succeeds best

38. Ibid, p. 204.
under heavy grazing, and produces a continuous succession of young leaves. Under unfavorable soil conditions, the plants are apt to be pulled out of the ground by the pasturing animals. This source of difficulty is small, however, where this crop forms only a part of the pasture mixture. Cattle graze it as well as they do timothy, but Kentucky bluegrass is more palatable.

**Biological Factors.** Whiteweed, sorrel, oxeye daisy, milfoil, and buckhorn are the most troublesome weeds that interfere with orchard grass seed production in the principal seed producing regions of Kentucky, Ohio, and Virginia. Orchard grass is rarely seriously attacked by insects or diseases. The tip burn, a very common trouble, is a characteristic trouble of the grass, but it seems not to have been scientifically investigated. Occasionally, small quantities of rust are found.

**IX. Italian Ryegrass.**

Italian ryegrass, a native of Southern Europe, is not truly an annual, but under farm conditions very few plants live more than one year. It can be sown in the fall in the southern half of the United States and on the Pacific Coast. Spring sowing is preferred in the regions with cooler winters.

**Climatic Adaptations.** Italian ryegrass is primarily adapted to moist regions with mild winter temperatures. In North America, it has

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done better in the Atlantic States, practically in the same region to which crimson clover is adapted, and on the Pacific Coast. A temperature of ten degrees below Fahrenheit zero does not injure a fall seeding of the crop; in fact, it may stand more severe cold. The grass languishes under mid-summer heat in the East.

Soil Requirements. Loam or sandy loam soils are preferred by Italian rye grass, but it does fairly well on clay loams. The crop will not tolerate standing water, but it is well adapted to irrigation farming on well drained land. Only small yields are to be expected on other than rich land. A remarkable number of cuttings of hay with a resultant large total yield can be made in a season under the most favorable conditions. No other grass grown in temperate climates grows so rapidly or recovers so promptly after cutting. Ordinarily, it will yield only two cuttings in a season, but with abundant moisture and fertilizer many more can be made. As many as from five to nine cuttings are common in Northwestern Europe where large amounts of fertilizer and liquid manure are used. The growth is so rapid that a growth of thirty inches in three weeks has been recorded. It is possible that such results might be duplicated on the Pacific Coast, but the fact that the crop languishes under mid-summer heat in the Eastern States discourages the expectations of such large yields there. Land watered with liquid manure in England is known to have produced as much as 60 to 120 tons of grass, or 12 to 20 tons of hay to the acre in one season. 44

44. Ibid, pp. 242 - 244.
**Economic Factors.** Italian ryegrass is an important hay, pasture, and lawn grass in the United States. Yields of from one to two tons per acre of hay are to be expected under normal conditions. It is more valuable as a hay plant on the Pacific Coast than it is in the rest of the country. The crop is much used in temporary pastures, especially as winter pastures in the South. When used for lawn mixtures, it produces a turf very quickly. In the South, it is a common practice to sow it on Bermuda grass lawns every fall so as to have a bright-green winter sward.45

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**X. Sudan Grass.**

**Climatic Adaptations.** Sudan grass is an annual plant belonging to the sorghum family. It is adapted to the same general climatic conditions as are the sorghums. It is distinctly a warm weather crop, but it will thrive and make good crops of hay as far north as southern Michigan and New York because of its short growing period. The crop is grown in nearly every part of the United States, but the results are unfavorable for the most part in the Rocky Mountain regions except in the irrigated valleys. Untimely frosts and continued low temperatures during the summer months preclude a successful growth at the higher altitudes. The upper altitudinal limits for hay production seem to be about 6,000 to 8,000 feet in New Mexico, Arizona, and Southern California; 5,000 to 6,000 feet in Colorado, Utah, Nevada, and northern California; and 4,000 to 5,000 feet north of those States.

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As it takes a month or more to mature seed after the crop is ready to cut for hay, the altitudinal limits of seed production are at least 1,000 feet lower than those for hay. It will grow and produce crops in regions of low rainfall; its ability to endure periods of drought is equal, yet not superior, to that of the best varieties of sorghum. In regions where drought is usually combined with extreme heat, such as in the South, Sudan grass outyields millet, but where the converse is true, as in Montana and the Dakotas, millet makes a slightly larger yield. Sudan grass has been successfully grown as a dry-land crop in spite of the fact that it requires a greater amount of water to produce a pound of dry matter than does corn, sorghum, or millet. 46

Soil Requirements. Sudan grass does best on a rich loam soil, but it is not at all exacting in its soil requirements because it has been grown successfully on almost every class of soil from a heavy clay to a light sand. The yield may be expected to be light where the soil is quite sandy. Soils that are cold, wet, and muggy are particularly unsuited to Sudan grass. Thorough drainage must be provided on such soils before attempts are made to grow the crop. Yields are reduced markedly by small amounts of alkali in the soil and stronger concentrations prevent profitable culture. 47

Economic Factors. In spite of the fact that Sudan grass is an annual and that it can be introduced easily into any rotation, it probably never will occupy the position of a staple crop in permanent rotations. Crops adapted to permanent rotations must serve either as

47. Ibid, pp. 8 - 9.
a "money crop" or as a soil improver. The demands for Sudan grass, either as hay or for seed, are limited. It has a place, however, as an emergency hay crop or for summer pasture, but as such it must compete chiefly with millet and sorgo. The yields of Sudan grass as compared with these two competitors at a considerable number of experiment stations are given in Table IV.

Table IV.

COMPARISON OF SUDAN GRASS WITH MILLET AND SORGO IN YIELDS PER ACRE OF CURED HAY.

<table>
<thead>
<tr>
<th>Regions</th>
<th>Yield per acre (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sudan grass</td>
</tr>
<tr>
<td>Northern Great Plains</td>
<td>2.28</td>
</tr>
<tr>
<td>Central Great Plains</td>
<td>2.31</td>
</tr>
<tr>
<td>Southern Great Plains</td>
<td>4.03</td>
</tr>
<tr>
<td>Timothy and Clover Belt</td>
<td>2.64</td>
</tr>
</tbody>
</table>


The yields of sorgo are considerably greater, but cured sorgo hay contains a larger amount of moisture. Sudan grass hay is also of better quality because of the coarseness of sorgo. Sudan grass is superior to millet in the Central and Southern Great Plains areas, but farther north the difference is slight. Sudan grass makes an excellent crop to grow for mixing with alfalfa in the irrigated regions south of Wyoming and Oregon. Where alfalfa makes up the entire ration of dairy cattle, they have digestive troubles, but the Sudan grass causes this to completely disappear. Its large yields as an irrigated annual hay crop makes it
quite valuable to the dairymen of the Southwest. It is the only grass which yields under irrigation in the Southwest even approximately as much as alfalfa, consequently it can be grown for a change of feed without greatly reducing the tonnage obtained from the land. 48

Sudan grass makes a good crop to grow in mixtures with legumes such as cowpeas and soybeans because, (1) Sudan grass grows strictly erect with a stem stiff enough to support the vines characteristic of most legumes; (2) the high protein content of the legumes and the low protein content of the grass makes a good mixture; and (3) Sudan grass seeded alone may give greater yields of hay than would the mixture, but the feeding value of the hay is considerably enhanced in the mixture. 49

Dairymen, and perhaps other livestock farmers, who depend upon Kentucky bluegrass for their pasture often find that Sudan grass makes a valuable summer pasture to carry their herds through the summer dormant stage of the bluegrass. The carrying capacity of Sudan grass for a short period is exceptionally high, consequently only a small acreage is necessary to supplement the bluegrass. Its carrying capacity during the hot summer months in regions of low rainfall and high temperatures is superior to that of any other grass or legume. There is some danger from prussic acid from Sudan grass especially after severe droughts and freezes, but Sudan grass is less likely to contain dangerous amounts of prussic acid than are the sorghums. 50

Sudan grass is an excellent forage crop because of its exceptionally high yields for a short season annual crop and because of its

49. Ibid, p. 10.
50. Ibid, p. 18.
palatableness in the green state. The fact that it can be made into hay quite easily, that there is but little waste in feeding it as hay, and that the sorghums and corn make larger yields of silage, limits the use of Sudan grass as a silage crop. Sudan grass mixed with cowpeas or soy beans can be grown for silage in humid regions. It makes a bright colored, palatable silage of high feeding value. 51

**Biological Factors.** Sorghum blight or red spot is a bacterial disease that is prevalent in the Great Plains, but it does little damage there except in wet seasons. It almost entirely prevents the profitable production of Sudan grass along the South Atlantic and Gulf Coasts. The kernel smut of sorghum does considerable damage, but it is not localized in its attack. Grasshoppers and chinch bugs do considerable damage to the crop wherever they are abundant. The sorghum midge very largely prevents the profitable production of Sudan grass seed from central Texas east to the Atlantic Coast. 52

**XI. Forage Sorghums.**

**Relationship With Other Sorghums.** Sorghums may be grown for grain, sugar, broom-straw, and forage purposes. The normal practice in Europe is to produce them for one of the first three purposes with their use as a forage crop being an incidental matter. The use of the crop for forage purposes far exceeds the other uses at the present time in the United States. 53

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The sweet sorghums or sorgo and the grain sorghums are the types of sorghum used for forage purposes. Sweet sorghums produce a higher yield of forage, and some of the earlier varieties produce good yields of seed. This grain, however, is of little value because of the tannin it contains. A sorghum which can be utilized as a grain crop in seasons of favorable rainfall and which can be utilized for forage, if the promises for a good grain crop are poor, is preferred in the Great Plains, consequently the grain sorghums furnish a considerable amount of the forage for this region. Sorgos are preferred for forage alone, but if the grain can be fed on the farm or marketed for cash the forage is of secondary consideration.

Physical Factors. In general, the climatic and soil requirements of forage sorghums are the same as those of the grain sorghums discussed in Chapter II. There are, of course, certain varietal differences that are too minute for a discussion of this type. The sorghums are of most value in regions too droughty for the successful production of the possibly more desirable forage and grain crops. Yet the huge quantities of forage per acre that can be produced in the warm, humid regions often are of great enough importance to cause the use of the crop in the humid regions. Figure 32 shows the principal grain sorghum and forage sorghum areas of the United States.

Economic Factors. The forage sorghums may be utilized as hay, fodder, soilage, and silage. No other hay grasses have been found equal to the sorghums for their ability to produce a large crop and certainty of producing a crop. Sudan grass and Johnson grass are equally as certain, but

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Figure S2. Boundaries of the principal grain-sorghum and forage-sorghum areas of the United States.

- Sweet sorghum or sorgo boundary.
- Grain sorghum boundary.

Source: Vinall, H.N. and Getty, R.E., Growing and Utilizing Sorghums for Forage, U.S.D.A. Farmers Bulletin 1158, Figure 1, p.4.
they both make smaller yields and Johnson grass becomes a weed on the 
fertile soils. Sorghum hay is not especially desirable as a market hay, 
because it is rather coarse and is difficult to cure sufficiently well 
for baling. It makes a good catch or emergency crop in many regions. 

A large part of the forage sorghum is cut and fed as fodder. Sorgo 
produces about one ton per acre more fodder than the grain sorghums, and 
the sweetness of the stems induces livestock of all kinds to eat it more 
readily. It may be shocked and left outside all winter with little or 
no damage in regions of light rainfall. Livestock can be maintained in 
good condition on well-cured fully matured sorghum fodder with little or 
no supplementary grain feed. The waste of the fodder may be decreased 
profitably by shredding if the feeding operations are on large enough 
scale to merit the possession of the necessary machinery. The crop may 
be used as a soiling crop provided care is used to avoid bloating and 
prussic acid poisoning. 

Formerly sorghum was not valued highly as a silage crop, but since 
farmers have discovered that the sour silage was the result of using 
immature plants, its use for silage has been greatly increased. Strik- 
ing results showing the superiority of sorghum over corn as a silage crop 
have been obtained by various experiment stations throughout the country. 
Table V. shows the higher yielding capacity of sorghum as compared to 
corn. Some, though not all, of this superiority over corn is lost in the 
succeeding crop, because most investigators admit that corn leaves the 
field in better condition for small grains than does sorghum. 

56. Ibid, pp. 21. 
Table V.
COMPARISON OF CORN AND SORGHUM FOR SILAGE PURPOSES.

<table>
<thead>
<tr>
<th>Station</th>
<th>Corn (tons)</th>
<th>Sorghum (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kansas Agricultural Experiment Station</td>
<td>11.61</td>
<td>13.02</td>
</tr>
<tr>
<td>Kentucky Agricultural Experiment Station</td>
<td>10.70</td>
<td>17.00</td>
</tr>
<tr>
<td>Michigan Agricultural Experiment Station</td>
<td>14.80</td>
<td>19.30</td>
</tr>
<tr>
<td>Tennessee Agricultural Experiment Station</td>
<td>7.40</td>
<td>14.20</td>
</tr>
<tr>
<td>Average</td>
<td>11.18</td>
<td>17.13</td>
</tr>
</tbody>
</table>


The fact that sorghum silage is a good feed is demonstrated by work at the Kansas Agricultural Experiment Station. Table VI. shows the results of this study. An acre of sorgo yielded considerably more silage, milk, and beef than an acre of either of the others. Kafir, a grain sorghum, lagged slightly behind corn in both milk and beef in spite of its slightly greater yield. The difference, however, is slight between these two; sorgo has quite an advantage on this rich land near Manhattan, Kansas. Although the same results may not be repeated elsewhere, it is safe to say that sorgo is a valuable silage crop and that it can readily compete with corn for this purpose especially in the drier regions.

Sorghums may be utilized as a summer pasture for livestock of all kinds, but there is more or less conflict of opinion regarding its value for this purpose. Well planned experiments have tended to discourage its use both for hogs and cattle.

Table VI.

A COMPARISON OF YIELDS OF SORGO, CORN, AND KAFIR FOR SILAGE ON RICH SOIL AT MANHATTAN, KANSAS.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield per Acre in</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Silage (tons)</td>
<td>Milk (Gallons)</td>
<td>Beef (Pounds)</td>
<td></td>
</tr>
<tr>
<td>Sorgo</td>
<td>18.02</td>
<td>3,750</td>
<td>1850</td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>11.81</td>
<td>2,760</td>
<td>1315</td>
<td></td>
</tr>
<tr>
<td>Kafir</td>
<td>11.88</td>
<td>2,719</td>
<td>1263</td>
<td></td>
</tr>
</tbody>
</table>

Source: Vinall, H. N., and Getty, R. E., Growing and Utilizing Sorghums for Forage, U. S. D. A. Farmers' Bulletin No. 1168, Figure 16, p. 25.

Biological Factors. Red-spot, formerly known as "sorghum blight", is probably the most troublesome of all sorghum diseases from a forage standpoint. It is most destructive in warm, humid climates like that of the Gulf Coast. It is usually present on the Great Plains, but it does little damage except in wet seasons. Kernel smut and head smut do some damage, but they are more serious to grain production. Grasshoppers do considerable damage in the semiarid regions such as parts of Kansas. Chinch bugs severely attack the small plants, but they are not generally territorial in their location other than that they avoid moist, shady places. The sorghum midge does considerable damage from central Texas east through the Southern States. It is of more importance to the Grain Sorghum producer because its damage is done in the sorghum heads. Ants often attack newly planted fields of sorghum by eating out the kernel thus preventing germination.

XII. Millet.

Millet, the third of the important short season crops often used as an emergency or catch forage crop, includes a number of cultivated annual species, which are used largely as forage crops in the United States but which are important human food cereals in the Orient.

Climatic Adaptations. Millet must have warm weather during the growing season if it is to succeed well. It does not do well at high altitudes or in other localities where cool weather prevails during the summer months. The crop grows well, however, in regions where the summers, though short are hot, consequently it is grown successfully in the most northern States of the country, especially those in the Great Plains regions. The fact that it matures quickly makes it possible to plant and harvest the crop during the few months of hot weather. The crop will mature in a shorter time in latitudes of longer days which provide plenty of sunshine such as that of the northern Great Plains area. A fairly abundant rainfall gives the best results. Millet is often referred to as a drought-resistant plant. It does have a low water requirement, but it lacks the ability to recover from the injury of a period of drought; sorghums can recover from such injury, but millet must depend upon its short growing season to escape periods of extreme drought. It is usually one of the first crops to show effects of dry weather conditions chiefly because of its shallow root system.

Soil Requirements. Millet does best on a rich, loamy soil that contains plenty of humus. It is a good crop for newly turned grass sod because the humus is advantageous to it and because it seems to aid in

61. Ibid, pp. 5 - 6.
Economic Factors. Millet is not important as a constituent in a regular cropping system; it is grown chiefly as a catch crop used to overcome an expected shortage in the hay supply, to occupy a field which would be idle on account of the failure of a regular crop, or because climatic conditions have prevented the seeding of such a crop. Its short growing season makes it admirably suited to such use. The crop is well adapted to a wide range both of soils and of climates; it does not make large yields either on poor soils or in dry climates, but it does do better than most other hay crops under such conditions. Sudan grass is a strong competitor because the quality of hay is superior, and its yields are nearly always larger (See Table V.); but this is partially counterbalanced by the necessity of a slightly longer growing season of Sudan grass.

Some attempt has been made to use millet as a soil-saving crop, but the sorghums and some of the small grains are better suited for this purpose. The completeness with which millet roots occupy the surface soil, the good stands usually obtained, and the vigor of the early growth makes millet an effective crop to use as a means of ridding a field of weeds.

One variety of millet, proso or hog millet, is grown as a catch grain crop, but under average conditions other cereals will outyield it if they are sown at the proper time. Other crops are more productive than proso in some localities even when sown late as catch crops. Buckwheat in the Northeast, the sorghum in the Southwest, flax in Minnesota and the Dakotas, and the common or foxtail millets in the humid sections of the

63. Ibid, p. 6.
64. Ibid, pp. 6 - 7.
United States produce more grain than does proso. Wheat, oats, or barley outyield it in pounds of grain per acre in nearly all localities where it is grown, but it often outyields the others in dry seasons. It matures from one to four weeks earlier than foxtail millet, and it usually produces more grain than foxtail millet. Proso grain is also a better feed; consequently if the millet is being grown for a crop of grain, proso is preferred over foxtail. It has the lowest water requirement of any grain crop, but it is less resistant to drought than other grain crops largely because of its shallow root system.

Biological Factors. Millet is less subject to destructive plant diseases than most other crops. Smut does some damage, but it does not affect the hay crop seriously. The damage it does to the grain crop in the semiarid regions is slight. The chinch bug and the army worm are the most destructive insect enemies of millet.

XIII. Reed Canary Grass.

Reed canary grass is a long lived perennial grass that tends to be coarse unless pastured rather closely. It is a native to the temperate zones of Europe, Asia, and North America. The largest areas of it in the United States are in Washington, Oregon, and northern California, but the increasing quantities of seed purchased in many sections of Eastern and North-central United States indicates an expansion in the acreage of Reed canary grass. Reports from these seedings indicate that successful

stands are being obtained and that forage yields are high. Figure 33 shows the regions of the United States to which reed canary grass is adapted. It can be grown only when irrigated in the dry sections of the Rocky Mountain States and the Great Basin, except in the meadows of the high mountain regions where moisture conditions are favorable.

**Climatic Adaptations.** Reed canary grass is best adapted to regions where the climate is moist and cool. It is not sensitive to heat or cold, growing quite well where winter temperatures drop below zero and where summer temperatures occasionally reach 100 degrees Fahrenheit, but it does not grow successfully where the average mean minimum temperature in winter is above 45 degrees. Cool weather is especially desirable during the dormant period of winter.

**Soil Requirements.** Schoth makes the following comments concerning the soil requirements of reed canary grass:

Reed canary grass makes its best growth on fertile, moist, or swampy soils, is especially suited to swampy or overflow lands of a sandy, mucky, or peaty nature, and makes an excellent growth on loams and clays of good fertility. The grass is not suited to salt marsh or alkali soils. Moving overflow is not detrimental to this grass during either the dormant or the growing season. Deep-ponded water is not especially injurious to it when dormant, if it does not remain too long, but deep-ponded water during the growing season usually results in considerable loss of plants. Winter overflow is apparently beneficial, because there is practically always increased growth following an overflow season.

Although naturally a moist or wet land grass, it makes a very good growth on high, well-drained, productive soil if supplied with ample moisture for spring and early summer growth. Its moisture-loving habits make it adapted to irrigation in cool climates.

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68. Ibid, p. 2.
69. Ibid, p. 2.
Figure 55. Source: ‘Setloa of th. Omt.d st»u. to .hldeed (Kuitry Onui. t. .d.ot«i. e^iotii, 1602

Region of the United States to which Reed Canary Grass is adapted.


Figure 21, p. 4.
Biological Factors. Reed canary grass is subject to the attack of no disease serious enough to attract attention. It is troubled very little by insects, but occasionally when grasshoppers and cutworms are numerous, slight damage is done.\footnote{Ibid, p. 1.}

Economic Factors. The long life, the long grazing season, and the large quantity of very succulent, palatable forage produced make reed canary grass a valuable pasture plant in regions adapted to its culture. It is better suited to dairy or beef cattle than to sheep or other kinds of livestock because of the type of land on which it makes the best growth. This plant is one of the earliest grasses to begin growth in the spring, and it will withstand pasturing well if not grazed too closely or too long continuously. The carrying capacity is quite high; under Pacific Coast conditions one acre of it on land well suited to it will furnish fresh feed for four dairy cows for seven months each year providing it is properly handled.\footnote{Ibid, p. 6.}

Formerly, reed canary grass was considered of little value for hay because of its coarseness, low palatability, and the large proportion wasted by livestock, but its use for hay is increasing rapidly as a result of more knowledge regarding the proper methods of handling. It cures rather slowly on fertile, moist lands because the large stalks settle rather closely to the ground after cutting. Curing is more rapid on higher, drier land because of lighter crops and drier soil. It heats very quickly and rapidly, consequently loss by fire or decay may result unless it is thoroughly cured. The crop is not a high class hay grass generally, but it has a valuable place on wet and overflowed lands.
The high yields per acre make it quite profitable under such conditions even though the palatability and nutritive value are not so high as for some other grasses. Four to nine tons of field cured hay to the acre are obtained, and in sections where limited pasturing is practiced two cuttings a year are possible. 72

A palatable, nutritious silage may be made from reed canary grass. A very high yield, ranging from 16 to 25 tons per acre, can be secured under normal conditions. Its utilization in this manner makes possible a cheap, succulent winter feed in sections where other silage crop often do not grow well or are too expensive to use profitably. When circumstances are such as to make it difficult or impossible to cure the crop for hay, it may be saved by making it into silage. Reed canary grass may be used for sowing, but its best use is as pasturage. 73

XIV. Rape.

Climatic Adaptations. Rape, a native of northern Europe, is best adapted to rather cool, moist climates such as prevail in portions of Canada and the Northern United States. It is successfully grown as a forage crop in many of the warmer and drier parts of the country. Biennial rape will not survive the winters of the Northern States, but it may be grown as a fall or winter pasture in the South. Rape will stand severe frosts. It can be planted early in the spring and will furnish considerable pasture before the summer heat causes it to languish. Excellent crops of rape are grown in the semiarid regions of the Northwest in favorable years or with a small amount of irrigation.

72. Ibid, pp. 7 - 8.
73. Ibid, pp. 8 - 9.
There are records of many good crops produced without irrigation under conditions of drought so severe as to cause the failure of corn and other farm crops.  

Soil Requirements. Rape will usually do well on any but light sandy and stiff clay soils which are usually deficient in organic matter, but for its best development it requires a rich, moist, loamy soil. Soils that will produce good crops of turnips, cabbage, wheat, and corn are generally suitable for rape production. It is a hard feeder and draws quite heavily on the nitrogen as well as the mineral constituents of the soil. Its power to utilize barnyard manure and fertilizer makes it an excellent crop to grow upon land recently treated. Reclaimed swamp land and recently cleared woodland are well suited to rape as a first crop.

Economic Factors. The principal use of rape in the United States is as a temporary pasture crop for livestock. It is especially well suited for hogs and is used quite often as a pasture for cattle and sheep. It provides fall pasture and very early spring pasture in the South. Rape can be seeded in mixtures with oats, rye, or other small grain for sheep and cattle pasture, but it is generally seeded alone for hog pasture. When seeded with a small grain, the grain to be cut and harvested, rape grows rapidly after the removal of the grain, making an excellent pasture in the late summer and fall when other pastures are inclined to be dry and of relatively little value.

75. Ibid., p. 7.
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CHAPTER V.

OTHER FIELD CROPS

I. Cotton.

Cotton, the great crop of the South and the greatest commercial crop of the United States, ranks second only to corn in value in the United States. There has been a rapid increase in the importance of the crop in this country since the invention of the gin in 1793. In the year of 1925 - 1926, the estimated world production was 27,700,000 bales; the United States produced 16,100,000 of these.\(^1\)

The distribution of cotton in the United States is shown in Figure 34.

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Figure 34. The production of cotton in the United States in 1924. Source: Baker, O. E., A Graphic Summary of American Agriculture Based Largely on the Census, U. S. D. A. Miscellaneous Publication No. 106, p. 81, Figure 38.

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Climatic Adaptations. The cotton plant is a native of warm climates. It is found growing wild in the tropical and warm temperate zones of both hemispheres, and its culture as a commercial crop is naturally limited to such climates. Latitude 37 degrees, near the northern boundary of Tennessee and North Carolina, pretty definitely marks the northern extremes of the cotton producing regions of the United States. A considerable amount of cotton may be grown north of this latitude when the cotton prices are very high such as they were during the period of the Civil War.2

The northern boundary of the Cotton Belt has a mean summer temperature of 77 degrees, and that of the southern part ranges between 80 and 85 degrees. The growing season for cotton is about 200 days along the northern margin of the Cotton Belt. Some parts of the Cotton Belt have a growing season of about 260 days, but this extra length in the southern parts of the Cotton Belt is of very little consequence because of the cotton boll weevil. As a rule, no cotton is produced after the first of August. A longer growing season means larger yields, but the heavy weevil infestation of the latter half of the growing season makes necessary the use of early maturing varieties that will mature bolls beyond weevil damage within a period of 110 days.3

Seasonal Climatic Requirements. A year may be divided into five distinct cotton seasons -- the soil preparation period, the seedling period, the ripening period, and the picking season. Each has a distinct optimum climatic condition.

The preparation of the soil for the cotton crop is largely completed by the first or middle of April. Most of the land is flat broken or is

broken by listing and bedding. This work starts as soon as the cotton of the preceding crop is picked on the large plantations, and it continues during the winter and spring season until completed. Freezing weather during the winter is not enough to greatly interfere with the progress of this work, but usually there is too much rain for the work to progress smoothly. The ground, when turned, should crumble freely, and if it is wet it will not do this. Only a moderate rainfall during this period is necessary if the desired conditions are to prevail. Occasional showers during April aid by firming the seed bed already made and by moistening hard, cloddy soil so that it may be well pulverized in the preparation of a seed bed. 4

Cotton seed are not adapted to deep planting, consequently frequent warm showers are desirable at planting time to keep the surface of the soil moist; continued heavy rains accompanied by cool weather are harmful. Although the seed must be moist to germinate, they will rot in the ground instead of germinating if kept wet any length of time. A scanty rainfall and drying winds cause the surface of the soil to become so dry that the seed will not secure enough moisture to begin growing. Cool weather retards the growth and root development of the young plant after it is above the surface of the soil. Drying winds bring about considerable disorganization of the plant in its life processes by drawing water from its tissues and causing a collapse of a part of its cells; a stunting of the plant and a permanent injury to its structure are apt to result from such a treatment. 5

5. Ibid, pp. 227 - 228.
The period of active vegetative growth extends from about the middle of May to about the middle of August. Best growth is made if a warm shower occurs about once a week during this period. Comparatively dry weather from the latter part of June until the first part of August is desirable where boll weevils are numerous. Growth of the plants is retarded somewhat, but the prevention of the multiplication of the weevils more than overbalances the loss from less growth. Rainy weather during the active growing period not only leads to greater weevil infestation but induces the production of too much vegetative growth. Proper cultivation is impossible, and weeds and grass cannot be held in check. Furthermore, the cotton plant develops numerous roots near the surface instead of sending them deep into the soil. If dry weather ensues later in the season the plants will suffer from a lack of moisture when it has only a shallow root system upon which to depend; the plant may shed squares, young bolls, and part of the leaves as a result of this condition. This excess rainfall lowers the soil temperature, prevents proper aeration, and interferes with the regular upward movement of the capillary water which carries to the plant roots their mineral nutrients from fertilisers and from the natural soil ingredients.\(^6\)

A desirable condition during the growth period is one in which there is an abundance of sunshine and warm uniform temperature. Wide contrasts between day and night temperatures and prolonged cold periods injure the plants and tend to cause them to check growth and mature prematurely. There should be no rains or only light rains during the period while the blooms are open, because rains interfere with pollination and cause some shedding.\(^7\)

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The fruit that has started to develop comes to maturity and most of the bolls open during the ripening period which extends from August to October. Further vegetative growth should cease and the foods stored in the plant tissues should be used in the production of seed and lint. Fortunately the autumn is often the driest period of the year in most parts of the Cotton Belt because dry weather checks vegetative growth, stimulates fruiting, prevents boll rot, and allows the seed cotton to be picked before the lint is damaged. Considerable range between the day and night temperature also assists in checking vegetative growth and in hastening maturity.

Rainless, sunshiny days are desired during the picking season which extends from August to November or later. Rains cause the discoloring of the lint of open bolls, and rains and wind combined result in many looks falling to the ground thus soiling the lint. Much boll rot, even in open bolls, is caused by frequent or daily rains. Before the coming of the weevil, frosts earlier than late November were not desired because they produce tinged, stained or discolored lint in the late bolls, because they reduce the yield by not permitting late bolls to ripen, and because the leaves crumble after frosts and some of the pieces lodge in the lint. Since the weevils are prevalent nearly everywhere, few of the bolls that set after the first of September amount to anything.

Soil Requirements. The yield of cotton is influenced by the physical, chemical, and biological characteristics of the soil the same as that of any other crop. Silty loams and clay loams give the best results, but soils that contain large amounts of organic matter or that have received large applications of nitrogenous fertilizers produce an excessive amount

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8. Ibid., p. 229.
of vegetative growth, especially when heavy rainfall occurs during the growing season. Only poor results may be expected from sandy soils which contain very little organic matter. Upland soils produce small plants and consequently small yields because of their general lack of fertility. Early maturity, which is oftentimes desirable, is brought about by a lack of fertility, but in general it does not pay to sacrifice yield to get early maturity. Rich soils, such as the bottom lands and the Black Prairie soils of central Alabama, produce large plants, but the maturity of the crop on such soils is much delayed.

The Ideal Soil. Collings has the following opinion of what an ideal cotton soil should be:

An ideal soil for cotton is one which is well drained, and which contains about equal proportions of sand, silt, and clay, together with a considerable amount of organic matter. While it should be well drained, it also should be a storehouse for moisture. For optimum growth conditions, the soil should have about 60 per cent of its pore space filled with water and 40 per cent with air.

A profitable crop of cotton can be produced, with proper consideration of the demands of the soil, on nearly all of the soil types existing in the Cotton Belt, but very few of them are ideal for economical cotton production. Commercial fertilizers may be used to make more productive the poor soils; drainage may be used quite often to solve the problem of soils that are too wet, but soils that are too dry must be abandoned so far as cotton production is concerned unless irrigation is possible at relatively cheap costs. Best results from the crop are secured on soils of medium fertility; a very rich soil, contrary to the case that exists with corn, is not desired for cotton.12

Other Soil Conditions. Sea Island cotton has different soil requirements from those of the Upland species. While the latter does best on clay or silt loams, the Sea Island cotton is better adapted to sandy silts. It will not grow well on the sandy silts of the Cotton Belt, for it appears to be adapted only to the sandy silt soils of a certain humidity.  

Cotton is very susceptible to cotton rust when grown in the Sand Hill Belt or on the sandy soils of the Coastal Plain. There seems to be some connection between the potassium content of these soils and the amount of rust injury because the above mentioned soils are all low in potassium. Both diseases and insects are prevalent to a greater extent on the bottom lands than on the neighboring uplands.  

Topography. Cotton generally is not limited by the topography of a region other than the secondary influence that it may have on the climate or the soil type. Field operations may be of either an extensive or a limited nature. The extensive operations would demand large, moderately level fields of a homogenous soil type, but those of the small scale may be done under much less ideal conditions. A negro with one mule does not particularly mind and can get along with small, irregularly shaped fields. Large machine operations are possible only in large, level fields such as those of Texas. Multi-rowed tractor planters and cultivators can be used under such circumstances. Mechanical pickers are not entirely satisfactory yet. A homogenous soil type that will be conducive of a uniform maturity is necessary if the picker is to be a success.

Cotton, like all other row crops, does not give rolling and steep land good protection from erosion. It is necessary to run the rows with the contours of the hill on the steeper slopes, and the rows should run up and down the slope under no circumstances. Such inconveniences add to the expense of handling the row crop on slopes.

**Economic Factors.** Cotton is quite a bulky product that cannot be hauled far before it is ginned and baled. Transportation costs, however, are quite small as compared with the value of the baled product, consequently cotton can be shipped long distances quite readily. Market locations have very little influence on where cotton may be produced. Furthermore, it is relatively non-perishable and can be stored for long periods of time with very little expense. It is one of the most staple agricultural products produced in the United States. This factor often causes it to be carelessly exposed to rain with a resulting lowering of quality.

The bulky nature of seed cotton makes necessary proper ginning and pressing machinery in each locality. If such facilities are unavailable, the cotton production of an otherwise well adapted region would be limited, but if an area of sufficient size to warrant the presence of a gin is well adapted to cotton production, there will be very little difficulty in getting established the essential processing machinery.

**Necessity of Cheap Labor.** Cotton picking is a laborious task that makes necessary an abundance of cheap labor. Attempts that have been made to use mechanical pickers have been generally unsuccessful and impractical largely because of the lack of uniformity in the ripening of the cotton. Other field operations in the production of the crop may be
performed quite well by machinery. This large amount of cheap labor required to harvest the crop is necessary for only a short time unless it is utilized during the rest of the year by substituting it for mechanical operations. A farmer might be able to plant and cultivate a large acreage of cotton with very little additional labor by using large power units. He must either maintain the labor necessary for harvesting the crop through the winter, spring, and summer or run the risk of hiring it when needed; the latter is not very satisfactory. If he is going to maintain the labor through three-fourths of the year, he probably will attempt to utilize it by substituting hand labor for mechanical operations throughout the year. Large quantities of rather cheap labor are necessary for cotton production under these circumstances.

Cotton is a good crop for the ignorant laborer. Although the crop responds well to good care, it is a crop that will produce something of a yield even if neglected. Cotton tends to discourage diversified farming because the cheap labor that goes with it tends to discourage the introduction of a more diversified farming. This is largely responsible for the fact that cotton regions are one-crop regions. Whenever cotton is a good price, the cotton cropper produces very little of the feed for his work-stock, and he usually has no productive livestock other than some for his own immediate use. Cotton, therefore, tends to exclude other agricultural enterprises from the area in which it is produced.

Supply and Demand Influences Upon Production Areas. The question of whether cotton will spread out into the less ideally adapted regions

bordering the main part of the Cotton Belt or whether it will fall to occupy the territory pretty generally well adapted depends considerably upon the price of cotton. When the price is low, the marginal cotton land will pass into other uses and a part of the better cotton land will be used to produce feed and food crops. The price need not be low in proportion to other farm commodities for this change to take place; cotton must be sold, but corn, wheat, and forage crops may be consumed on the farm thus making it possible for the farmer to exist even though their cash value may be exceedingly low.

The demand for cotton depends upon both export trade and domestic consumption. As much cotton is exported, the price to the American farmer is pretty largely dependant upon the foreign demand and the international monetary situation. The Cotton Belt may decrease in size considerably if the foreign markets fade away.

The domestic utilization of cotton is changing considerably. The per capita consumption has not changed materially since 1900, but there have been decided changes in the uses made of the product. There has been a decided decrease in the use of cotton for clothing because of the competition of silk and rayon, and because of the decrease in the weight and number of undergarments worn by women as well as lighter-weight underwear now worn by men during the winter. Increased popularity of "styled" cotton dresses, men's cotton summer suits, and beach pajamas has resulted in a partial counterbalancing of the decreases mentioned above. Industrial uses, however, are more largely responsible for maintaining the per capita consumption. Automobile and tire manufacturing, the building trades, and packaging interests are demanding greater amounts of cotton than formerly, but jute and paper are particularly
serious competitors of cotton for the industrial uses.16

This shift from clothing to industrial uses will tend to cause more fluctuations in the demand for cotton. Household or clothing uses tend to be fairly constant, but the industrial uses will depend quite largely upon the general economic situation. As consumption shifts from the stable uses to the more erratic demands, the general demand for the product will fluctuate considerably with the changing purchasing power of the people. This will result in considerable shifting of cotton producing regions in the marginal areas of the Cotton Belt. Supply and demand primarily affect the production organization of the marginal producer.

Competitive Crops. The areas adapted to cotton production are more limited than those of some of the other major farm commodities, consequently cotton will have prior claim to these areas. Corn and wheat are pretty generally excluded from cotton regions. When the relative corn-cotton prices are greatly in favor of cotton, much of the corn needed for local consumption will be shipped in from other regions, but as the relationship narrows some corn will be produced locally. The cotton farmer will attempt to produce a large part or all of the feed he needs when the cotton price gets exceptionally low.

The relationship between wheat and cotton is practically the same, but wheat rarely is a major competitor with cotton in the Cotton Belt. This is because wheat is less ideally adapted to the climate than is corn, because wheat is worth more per pound than corn and may be shipped farther, and because wheat is a small grain while corn and

cotton are intertilled crops. The tendency, therefore, is for the cotton farmer to turn to corn and to forage crops rather than to wheat.

The tendency is for the cotton farmer to ignore rotations and to produce cotton alone. Cotton, however, is well adapted to rotation farming. It is a cash crop and an intertilled crop. Some people use it as the chief crop of the rotation, with the other crops used for supplementary and complementary purposes such as maintaining soil fertility, utilizing labor and power, and protecting the soil from washing. Other farmers, especially the livestock farmers of the Cotton Belt, use cotton only as a secondary cash crop to more fully utilize the available resources. Its place as an intertilled crop makes it a competitor of corn and tobacco, but as previously mentioned it has first choice to the area adapted to it because of the greater limitations from a climatic standpoint. It is also a competitive crop with corn and tobacco from a labor, power, and equipment standpoint.

Cottonseed has become an important by-product of cotton lint production. The milled products are oil and meal which are finding considerable outlet for industrial purposes and as food and feed products. These outlets, however, are not wholly limited to cottonseed products because soybean and linseed oil and meal products may be used for many of the same purposes.

The exact influences of the demand for cottonseed products upon the production areas of cotton are rather indefinite and generally insignificant. A marginal cotton production area which is near a cottonseed mill may find this advantage of great enough importance to induce the growing of cotton, but another area similar in all respects except that it has a less valuable outlet for the cottonseed may not grow the crop. These
factors are purely a matter of transportation costs and market.

**Biological Factors.** Cotton is subject to the attack of many insects and diseases. Brown makes the following statement concerning the attraction cotton seems to have for insects.

The cotton plant has several different means of attracting insects. On the midrib on the under side of each leaf there is a nectary, a shallow cup-shaped structure that contains a droplet of sweet fluid; at the base of each bract on the outside of the square is another nectary; inside of the flower near the base of the petals are others. Many insects visit the plants to get the nectar. Others come to the cotton flower to gather or feed on the pollen. The tissues, or substances of seeds, leaves, stem, and roots of cotton plants, are rich or moderately rich in nutrient materials. These invite various insects to feed on the plants and in some instances to live within their tissues.

Of the many insects that visit cotton plants, a few are beneficial in that they foster pollination or prey on harmful insects. A comparatively small number of others are injurious to the plants. The greater number of the insect visitors may be classed as neutral, being of no help to the plants but doing no harm. Of the harmful insects the boll weevil, the pink boll worm, the cotton leaf caterpillar, and the boll worm are the most destructive.

**The Mexican Boll Weevil.** The Mexican boll weevil, a native of Central America, does its heaviest damage during the rainy or cloudy weather during the period when the plants are blooming most; this usually extends from the latter part of June through the first half of August. Hot, dry weather during this period causes a heavy mortality of the larvae thus checking the weevils. Warm, open winters are favorable to the weevil, but low winter temperatures are not as effective in control of the weevil as once thought. They certainly are not so effective as dry weather during the summer.

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The boll weevil has caused the production of earlier varieties of cotton to avoid damage, with the result that regions of shorter growing seasons are not at so great an economic handicap. It has caused many farmers to abandon the one-crop way of producing cotton; other crops and livestock are increasing in importance in such areas. Regions with ideal weather conditions for the weevil are being forced to abandon the crop almost altogether. The boll weevil is a classic example of what an insect may do to alter the production areas of a crop.

Other Cotton Insects. The other cotton insects are not causing any phenomenal changes in the production areas. They are pretty generally well adapted to any region in which cotton can be produced.

Cotton Diseases. Cotton wilt, anthracnose, angular leaf spot, and root knot are the most troublesome diseases attacking cotton. Wilt is most prevalent on sandy or sandy loam soils, but it is not unknown on clay and other soils. It must be contended with in all the southern and eastern states, but it is most prevalent in eastern South Carolina, southwestern Georgia, and southeastern Alabama. 19

The root knot, caused by a nematode, is found in most areas where the cotton wilt prevails. It is most prevalent on the sandy coastal plain from Virginia to Texas. 20

Cotton anthracnose, or pink boll rot, is probably widespread in most of the cotton-growing regions of the world. The damage, however, is considerably greater during years when there is much rain, especially during late summer and fall. It is greater in the more humid regions such as those near the seacoast and in the Mississippi Delta. It is also

prevalent on rich land where plants become large. 21

Rust, sometimes called black rust, yellow leaf blight, and potash hunger, is a physiological trouble caused by unsatisfactory cultural conditions. It seems to be quite common on the poorer soils throughout the Cotton Belt. Angular leaf spot is widely distributed throughout the cotton-producing states of the United States. Its spreading is favored by rainy weather. The Texas root rot does considerable damage in Texas, but it has not been found east of that state. Diplodia boll rot causes much damage to the cotton crop in Louisiana. It is at its worst on the alluvial soils and bluff lands. 22

Social Factors. The necessity of cheap labor has been mentioned previously, but connected with this factor we have the matter of finding a crop that is adapted to a poor, ignorant, and shiftless population which needs considerable supervision. Cotton seems to be better fitted to such conditions than are the feed crops and livestock, the bread grains, or the fruit and vegetable crops.

Smith points out that numerous attempts have been made to do away with the one-crop system of the Cotton Belt. He makes the following statement:

The whole South rang with the din of sermons exhorting the farmers to grow many crops. When it came to a consideration of the negro tenant, no one wanted to mortgage his prospective crop of pigs. It was too easy for them to "run away". If his crop were hay or beans or oats the rain might ruin it. Indeed, nothing was so easy to mortgage as cotton because it was easy to grow, easy to keep, nothing could eat it (a point of great importance), and it had to be taken to the ginney before it could be sold.

21. Ibid, p. 277
The people who are born and raised in the regions where cotton is the one crop know little or nothing else. Their whole lives seem to be built about the crop. Even when they move to non-cotton producing regions, they often attempt to introduce the crop rather than to adopt the prevailing community practices. Cotton, therefore, is often carried into marginal regions not because it may be especially better fitted than competing enterprises but because the people want it.

II. Flax.

Flax is grown for seed and for fiber. It ranks about seventh in acreage and eighth in value as a grain crop in the United States. About 95 per cent of the total crop is produced in the states of North Dakota, Minnesota, South Dakota, and Montana. Figure 35 shows the distribution of flax in the United States.

General Soil and Climatic Factors. Flax can be grown under a wide range of soil and climatic conditions. It does best, however, on the clay loam soils of the North Central States where the summer temperature is moderate and the rainfall is adequate. The center of the flax producing area has an annual rainfall of from 20 to 30 inches, but the rainfall diminishes to near 14 inches as the western edge of the flax production area is approached. The crop depends largely upon summer precipitation in the latter region. Flax with short straw and non-uniform fiber is produced under these dry conditions. Only the highest yielding seed-flax varieties should be grown in such regions. A fair

quality of fiber suitable for those industries which heretofore have
used imported flax tow and waste can be produced in the principal
flaxseed-producing area where the annual rainfall is 20 or 30 inches.

Climatic Conditions for Fiber Flax. It is useless to expect to
produce a good quality of fiber flax without suitable climatic condi-
tions. Fiber flax probably responds better to a favorable climate than
any other general agricultural crop. If it is grown under dry conditions
the fiber flax is likely to be short and woody containing a harsh, dry
fiber. An abundance of moisture and cool weather during the growing
season are required. Many light showers are much better than are down-
pours. Regions subject to fogs and dews which supply moisture in

25. Dillman, A. C., Production of Seed Flax, U. S. D. A. Farmers'
Bulletin No. 1328, p. 3.
addition to the rains, such as that found around the Great Lakes, are ideal locations for the production of fiber flax. Excellent climatic conditions for fiber flax are found in the Willamette Valley in Oregon and in the Puget Sound region in Washington where there is cool, moist weather from March to June followed by warm, dry weather in July, and where there is an absence of storms that will cause lodging. 26

Cloudy days are desirable during the growing season of the flax because they help lower the temperature and conserve the moisture. A hot, dry day may cause the plant to branch and later produce seed after it has reached a certain stage in its growth. The plant will continue to grow not indefinitely but for a longer period if the weather does not turn warm. This additional growth below the lowest branches means a greater tonnage of straw, a longer and higher yield of fiber, and a straw with a higher percentage of fiber. The fiber of commercial value is found only in the straw from the ground to the lowest branches or beginning of the panicle. Following the cool, moist weather of the growing season, warm, dry weather is best for curing the seed after the growth of the stalk as well as for threshing and for drying the straw after retting. If dew-retting is practised, there must be enough moisture during this period to ret the straw. 27

Soil Requirements of Fiber Flax. Both the yield of flax and the quality of fiber in the straw are influenced by the type of soil. The ideal soil for fiber flax is a medium-heavy soil that is well drained. It should be of good fertility. The crop will grow on very light soils.

27. Ibid, p. 5.
but the yields are usually low largely because of the lack of moisture in dry weather. The necessity of working the soil early in the spring and the fact that young plants will be killed if water stands on the surface after a heavy rain make good drainage quite valuable. Light loams with a clay subsoil that will retain moisture have given good results with fiber flax. Muck soils may be used, but they produce a coarse fiber that lacks strength. Potash and phosphorus fertilizers will offset this fault if they are not too expensive. Early plantings are necessary on heavy soils to avoid hard crusts.23

Economic Factors. Flaxseed is marketed in much the same manner as are the small grains. Transportation costs are of great enough importance to give the areas closest to the mills a considerable advantage. Linseed oil is used for painting and manufacturing purposes, and the linseed meal makes a good protein supplement for livestock feeding. Up until recently the linseed oil had no serious competitor as a paint oil, but at the present time increasingly larger quantities of soybean oil are being used for this purpose. The flaxseed industry may receive a severe blow if further trials and investigations prove that soybean oil can be substituted readily for the linseed oil. Cottonseed meal and soybean meal are already strong competitors with linseed meal as a livestock feed.

Flax fiber is used primarily as a textile product; much of it is manufactured into fine linen fabrics. Other uses of it are of a more industrial nature. The automobile and furniture industries use much of it as upholstering tow, and large quantities of the yarn are used for twines, binding materials, and threads.

One difficulty in producing fiber flax in new areas is that the straw is rather bulky. Scutching milk should be within a reasonably short distance from where the flax is grown. Furthermore, the handling of the crop during the harvesting and retting period demands considerable skill and knowledge. Readily avoidable circumstances which lower the quality of the fiber cause much loss to the ignorant and unexperienced flax producer.

Flax must be considered as a small grain when adapting it to a rotation. It has similar characteristics in the seed-bed preparation, the labor power, and equipment requirements, the lack of intertillage, and its use as a nurse crop, but it does not compete with the cereal grains in its marketable form. The fact that cereal grains are primarily feed and food crops and that flax is a fiber or an oil crop decreases the number of competitive crops with which flax has to contend. Its limited use, however, decreases the total acreage that can be devoted to the crop. The small grains have an advantage in that they may be consumed on the farm, sold for local consumption, or sold through regularly established market channels; flax is marketed only as a cash crop. The straw from seed flax production may have some feeding value, but this is of a minor nature.

Flax is not well adapted to weedy areas because it does not shade the ground very heavily. It cannot compete with weeds as well as the other cereals, consequently weeds are sometimes a serious problem in the flax regions. This lack of shading and crowding makes it an excellent nurse crop with which to seed clover and alfalfa.29

Biological Factors. Weeds are quite troublesome to flax production, especially to the production of fiber flax. The best means of avoiding the trouble of weeds in the processing of the flax is to plant clean seed on weed-free land at an early date. Large weeds, such as Canada thistle, dock, mustard, falseflax, dogfennel, and French pink; the twining vines, such as dodder, bindweed, and morning glory; and the grasses, such as quack grass, foxtail, chess, and barnyard grass are especially undesirable to fiber flax production. Weed seeds difficult to fan out of flax-seed are French pink, falseflax, foxtail, and wild buckwheat. Areas where these weeds are prevalent must be avoided.

Flax wilt is one of the worst diseases attacking the crop. It seems to be prevalent throughout the flax producing regions. Flax rust also occurs in nearly every region where flax is grown. Heat canker is best controlled by not seeding the crop on land likely to crust.31

III. Tobacco.

Areas of Tobacco Production. Tobacco, a staple cash crop, may be grown successfully in all latitudes from southern Canada to the Tropics and on a wide range of soil types. The particular soil and climatic conditions under which the crop is grown influence the commercial value of the product to a greater degree than that of almost any other important crop. The tobacco industry so well recognizes these facts that it looks to certain well-defined production areas for its supply of the various classes and types of leaf required. Necessary facilities for marketing the product are available in all these tobacco producing districts.

Garner, in commenting upon the expansion of tobacco culture into new areas, makes the following statement:

Each important district produces a tobacco of certain well-known characteristics which make it desirable for special purposes of manufacture or export. Moreover, in practically all of these districts the production can be readily increased to meet any increased demand at profitable prices. For these reasons efforts to introduce the commercial growing of tobacco in sections outside of the established producing centers are likely to result in failure, either because the leaf produced is not quite right in type or satisfactory marketing facilities are not available. Furthermore, any development of the industry in a new section on a large scale, which would be essential for economical marketing, would most likely lead to overproduction and, as a consequence, unprofitable prices. As a matter of fact, overproduction is a constant menace in all of the established centers of tobacco growing.

Classes and Types of Tobacco. Three general classes of tobacco, (1) cigar tobaccos, (2) export tobaccos, and (3) manufacturing tobaccos, are easily distinguished. The latter two classes have much in common as regards cultural methods and requirements. Some types are used both

33. Ibid., p. 1.
for manufacturing and export purposes, consequently these two classes can be considered together as distinguished from the cigar tobaccos. Wrapper leaf, binder leaf, and filler leaf are the three principal types of cigar tobaccos. The major manufacturing and export tobaccos are such types as the flue-cured, Virginia sun-cured, White Burley, dark fire-cured, one sucker, Green River, and Maryland. Each of these types has its special soil requirements and its definite cultural methods.

**Climatic Factors.** Climate, a factor influencing the general distribution of tobacco in the United States, affects especially the quality of the crop. Northern climatic conditions favor the production of cigar types, the leaves of which possess characteristics of large size, thinness, and weak aroma. Farther south the tendency is toward the production of a somewhat smaller leaf having more aroma and heavier body, as seen in the cigarette, pipe-smoking, chewing, and export types.

Generally speaking the best quality of tobacco and the most satisfactory yields are obtained when the seasonal conditions are favorable for a rapid, uninterrupted growth of the plant, such as fairly high temperatures and a moderate, evenly distributed rainfall. The tobacco plant is not killed readily by drought, but is reduced in size, the leaves not only being smaller but are abnormally thick, close grained, contain an excess of gum and have poor combustibility. A crop produced under droughty conditions has a greater yield than the size of the plant would indicate; furthermore the leaf is resistant to decay in the processes of fermenting and aging. Tobacco quickly succumbs to a water-logging of

34. Ibid., p. 2.
the soil. A comparatively wet season results in a large growth and thin, tender leaves, deficient in gummy matter, having free burning properties, but susceptible to injury through decay in the curing and fermenting processes. The yield is lower than one would expect from the apparent size of the plant. Killing frosts or freezing temperatures seriously damage tobacco in the green state, and there is always danger of partial or total loss from frost in northern regions. The plant is peculiarly susceptible to severe damage from hail storms and strong winds. 36

Garner, et. al. 37 state that for the best yields in tobacco districts of the Ohio Valley, the weather conditions as compared with the normal climate in that region should be as follows:

May should be moderately dry for a good seed bed, and cool to harden the tobacco plants. June should be moderately warm and wet to insure growth when the plants are set out, although the warm and wet weather may develop injurious parasitic diseases. July rainfall and temperature should be about normal, as too much rain interferes with cultivation; and if the rainfall is inadequate, the temperature should be below the normal. August should have rain enough to produce a good-sized leaf after topping. Warm and wet weather makes the best growth, but is more likely to cause the development of leaf spot. Hot and dry weather is very detrimental, hence if the rainfall is less than normal the month should be cool. If the growing season is moderately wet, with a uniform supply of moisture, the best growth will be with the temperature somewhat above normal. But if drought prevails or frequently occurs, the best results are obtained with the summer somewhat cooler than normal.

Soil Requirements. The most important factor influencing the development of those properties of the tobacco leaf which determine its usefulness in the trade are the physical and chemical properties of the surface soil and the subsoil. A thin leaf of relatively large size, light in

56. Ibid, p. 419.
37. Ibid, pp. 419 - 420.
color and body, fine texture, and weak aroma is produced on light sandy
loam soils low in both water holding capacity and content of soluble
mineral matter. The heavier soils, which contain more silt and clay, tend
to produce a leaf of small size, dark color, heavy body, and strong aroma.
The influence of the soil on the quality of the tobacco is so pronounced
and important that commonly certain restricted localities within the
principal producing districts enjoy a high reputation for the special
merit of their tobacco. It is not possible to analyze fully the remark-
able effect of these seemingly slight differences in soil type and
composition on the quality of the tobacco produced in the present state
of knowledge of the subject. 33

The cigar wrapper and binder types of tobacco produced in the
Connecticut Valley and in the Quincy, Florida district, are grown on
sandy and sandy loam soils which contain very little clay in the subsoil
and have a low water holding capacity. The cigar binder-leaf tobacco
grown in Wisconsin is produced on sandy loams, loams, and light clay loams,
and the cigar-filler tobacco of Pennsylvania and Ohio is produced on silt
and clay loams. The Pennsylvania soils are largely of limestone origin.
The soils adapted to binder-leaf tobacco are considerably lighter and
have a lower water holding capacity than those adapted to cigar-filler
tobacco. The manufacturing and export tobaccos are produced on somewhat
heavier soils which have a higher water holding capacity. The highly
fertile phosphatic limestone soils, such as found in the bluegrass region
of Kentucky and southern Ohio are well adapted to Burley tobacco production.

It is on this type of soil that the crop is most widely grown. The dark fire-cured and dark air-cured tobaccos of Kentucky, Tennessee, and Virginia are produced largely upon heavy silt and clay loam soils which have a high water-holding capacity. Flue-cured tobacco is grown on gray sandy and sandy loam soils of low natural fertility. The texture of the subsoil upon which this type of tobacco is grown largely determines its body and texture. The cigarette and granulated pipe-smoking tobaccos are produced chiefly on the lighter soils which have little clay in the subsoil. The plug-filler and wrapper grades are produced on somewhat heavier soils with more clay in the subsoil.

As tobacco will not tolerate too much water, low and soggy soils should be avoided. The land should be well drained so that water after rain does not stand for hours. Tobacco does best on a soil that is slightly acid such as one that will require about a ton of pulverized limestone per acre to correct its acidity or to make it neutral. Root rot attacks are much more severe on limed soils.

Topography. The fact that tobacco is an intertilled row crop suggests that level to rolling fields will reduce materially the costs of seed-bed preparation, setting plants, and cultivation. When the size of the operations are so small that one man with no more than one horse can tend to the crop, the necessity of large, level fields is less pronounced.

Intertilled crops on steep, hilly land are subject to erosion, consequently such land is no more ideal for tobacco than it is for corn or cotton. To minimize erosion, rows should run with the contours of the slope. A winter cover crop is also necessary to protect the land when it

would be bare otherwise.

**Economic Factors.** Since tobacco is valuable per pound, it may be shipped long distances. Consequently, country markets and warehouses need not be in each tobacco producing community. New areas within moderate trucking distances from the country market are not at a material disadvantage so far as transportation costs and availability of market are concerned. The tobacco trade, however, is very exacting in its demands, and tobacco grown in new areas is likely to be marketed only after the greatest difficulty.

The product of an acre of tobacco has a relatively high value as compared with the other major field crops. Furthermore, the amount of man and horse labor required to grow and market an acre of tobacco is much higher than that of the other field crops. The production of an acre of corn required, on the average, about 19 hours of man labor for that husked in the field (survey made in Indiana, Iowa, Illinois, Nebraska, and Kansas) and about 52 hours for that husked from the shock (survey made in Pennsylvania, Maryland, Delaware, Ohio, and Virginia). The horse labor was 46 and 56 hours respectively. Records show that an average of 262 hours of man labor were required to produce an acre of Kentucky dark fire-cured tobacco, 375 hours for an acre of Burley tobacco, and 403 hours for an acre of Georgia bright tobacco. The horse labor required per acre was 89, 95, and 90 hours respectively.

The intensive nature of tobacco production is further illustrated by the small area of 4.3 acres per farm reporting tobacco grown in the United

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States in 1929. This average does not vary widely throughout the country. The one exception is the highly specialized cigar-wrapper district of New England where the acreage average 10.7 acres for each tobacco farm. These acreages make up only a small part of the total cultivated acres per farm. Two factors influencing the production areas of tobacco arise from this situation; they are: (1) as an increased demand for tobacco forces the price upward, the tendency will be to expand production on the farms already producing the crop rather than to expand into new areas, and (2) the extremely small acreage per farm makes the crop poorly adapted to crop rotations.

Expansion of Tobacco Acreage to Meet Price Increases. Although all the cultivated area of a given farm is not adapted to tobacco culture, the farms growing the crop are not doing so to a full capacity so far as land and equipment is concerned. Labor is the largest single item of expense, consequently when tobacco prices are low in comparison to labor costs, farmers depending on hired labor reduce their tobacco acreages.

A considerable part of tobacco is produced by share-cropper tenants. When higher prices invite an expansion of production, the farmer who has the equipment, experience, and suitable land for tobacco production is in a better position to expand by hiring additional labor than is the farmer in the new area who has nothing but a possibly favorable set of soil and climatic conditions. Other crops, such as corn and cotton, are produced much more nearly to the capacity of the farms on which they are well adapted, and when increasing prices make possible an expansion, much of the expansion will take place in the marginal areas rather than on the

43. United States Bureau of the Census, Agriculture, General Statistics, Table 47, p. 91.
farms already producing the crop.

High tobacco prices plus relatively high labor costs would tend to cause production to expand into the marginal areas. Increased production from hired labor is discouraged, but that from operator's labor is encouraged. An increased gross income and a substantially greater increase of costs of production would not be good economy, but the farmer in the marginal area may not be utilizing fully the labor available on his farm. There will be a proportionately smaller number of farmers already growing tobacco who will expand their operations under the latter circumstance as compared to the former situation.

Adaptability of Tobacco to Cropping Systems. The ideal rotation crop will occupy at least one full place in the cropping system. Tobacco cannot do this on the normal farm because of the small acreage that can be grown under ordinary circumstances. A special place must be provided for it. Tobacco is an intertilled crop and will occupy such a position in the rotation. It will be necessary to set aside a small part of the intertilled field each year for the tobacco crop, or it will be necessary to provide some sort of a secondary or minor rotation. Additional temporary fencing may have to be done especially if the farm is stocked with considerable livestock. A corner of each field permanently fenced off would call for a considerable investment in fencing and would seriously interfere with such crops which follow the tobacco crop, as wheat and corn.

A secondary or minor rotation usually is more satisfactory because many farms have an odd shaped or poorly located piece of land that is difficult to work into a major rotation. Large, square fields are not so essential when the operations are of an intensive nature that demand much hand labor.
Furthermore, small irregularly shaped fields are expensive to cultivate under more extensive methods. A farm on which there are such fields may find it profitable to arrange a minor rotation including tobacco, providing the land in question is suited to tobacco culture.

Tobacco fits into the cropping system of many livestock farms very poorly; it is purely a cash crop and it cannot be utilized for feed purposes even when it has no sale value. If it takes the place of a sort of minor rotation with the major system adapted to livestock, it may be exceedingly profitable to the farm and to the tobacco crop to utilize through livestock the remaining crops of the minor rotation. Other farms with a small livestock system may wish to carry the livestock on the minor rotation and leave the major cropping system intact within itself. A combination tobacco-livestock rotation is necessary under such circumstances.

Tobacco is a crop admirably suited to the needs of the small operator who has a limited amount of land, equipment, and capital. Labor is his most plentiful possession, and a small field of tobacco will furnish him a means of utilizing more of this labor than any other major field crop. There is work to be done throughout most of the year. Other crops demand the operator's attention at intermittent intervals with long periods of idleness. The large operator who has at his disposal the choice of a large number of enterprises may fully utilize his labor by combining them to the best advantage, but the small operator with his limited facilities cannot do this. A small field of tobacco, therefore, gives him a means of combining his large amount of labor and his small amount of land to very good advantage. Areas where there are a large number of small operators are much more adapted to tobacco than areas where the farms are large and where livestock forms a major part of the enterprises of the farms.
Diseases Affecting Tobacco Production. A number of diseases attack the tobacco plant. Black root rot, one of the most important and widespread diseases affecting the plant, has about the same effect upon the plant as an infertile soil, lack of fertilizer, too much water, and the like. The disease is caused by a fungus that lives in the soil from year to year; it also attacks cowpeas, the clovers, and other legumes. It is greatly favored by cool weather such as occurs in a late, wet spring. Very hot weather may soon check the disease, causing the plants to develop new roots near the surface of the ground. Areas subject to late, cool springs should avoid the production of tobacco. The injury may be reduced by resting the land for several years or by the rotation of crops if legumes are avoided.44

Tobacco may be grown very successfully in rotation with various other crops on many types of soils, but on other types of soil certain crops, when preceding tobacco in the rotation, may cause a serious depressing effect upon the growth of the tobacco. This trouble, known as brown root rot, may be expected when timothy, rye, corn, and the common legumes precede the tobacco. Heavy fertilizing and liming fail to correct this trouble, but it seems to be obviated or corrected by continuous culture of tobacco or by resting the land.45

Tobacco wilt, a serious bacterial disease that attacks a number of plants besides tobacco, occurs chiefly in Granville County and the adjoining counties of North Carolina and in the cigar-tobacco district of western Florida. The only successful means of controlling the disease is

by the systematic and persistent rotation of crops. The rotation should contain no crops that are attacked by the disease other than tobacco, and tobacco must not be grown on the land more often than once in four or five years. Immune crops that may be used are corn, cotton, sweet-potatoes, redtop, cowpeas, wheat, oats, rye, the clovers, and other grasses. Ragweed, which is so common on tobacco fields, is attacked by the wilt organism, consequently resting the land will not give good results.

The nematode, a minute eelworm, bores into the roots of tobacco causing the trouble known as "root knot". The disease was formerly thought to be more severe on the light, sandy soils of the South than elsewhere. It is readily controlled by the rotation of crops, provided that only highly resistant crops are used and that tobacco is grown only every third or fourth year. The crops that may be used in the rotation are the Iron and Brabham varieties of cowpeas, velvet-beans, corn, wheat, oats, rye, sorghum, peanuts, and grasses, but most other crops, including cotton and the ordinary varieties of cowpeas, should be avoided.

"Frenching" is not an infectious disease and is caused by some unfavorable condition of the soil. It seems as if defective drainage is a cause of the disease, and deficiencies in plant food may cause symptoms of the trouble.

Leaf spot diseases are more noticeable than the root rots, but the latter probably do more damage. There seems to be no specific remedy

46. Ibid., p. 19.
47. Ibid., p. 19.
48. Ibid., p. 20.
for the leaf spot diseases, but their progress is usually checked by dry weather. The diseases are more destructive in periods of wet weather. Although the plant is subject to attack at any stage of development, it seems to be particularly susceptible at the time it reaches maturity, consequently areas where wet weather is common during this period should be avoided. Other factors contributing to the susceptibility of the plant to the leaf spot attacks are an abundant supply of nitrogen in the soil or fertilizer and low topping of the plants. A liberal supply of potash tends to increase the resistance of the plants to the disease.\textsuperscript{49} 

Potash hunger is a trouble caused by an insufficient supply of potash in the soil for normal growth and development of the tobacco plant. It is readily controlled by using an adequate supply of potash, and it is more commonly seen on light sandy and sandy loam soils, especially in the coastal plain portion of the flue-cured district.\textsuperscript{50} 

Magnesia hunger or sand drown prevails on some of the light sandy and sandy loam tobacco soils, more especially in seasons of heavy rainfall. It is caused by an insufficient supply of magnesia and is readily corrected by the use of a fertilizer supplying 10 to 20 pounds of magnesia per acre in an available form.\textsuperscript{51} Areas where the natural conditions are favorable have a distinct advantage. Other diseases attack the crop, but they are not so important or are not territorial in their attacks.

\textbf{Insects Affecting Tobacco Production.} The control of the attack of insects is one of the most troublesome and expensive features of tobacco

\textsuperscript{49} Ibid, pp. 20 - 21.  
\textsuperscript{50} Ibid, p. 21.  
\textsuperscript{51} Ibid, p. 22.
culture. They seem to be particularly troublesome in the southern districts where the mild winters do not greatly check their growth. The tobacco flea beetle, the tobacco wireworm, cutworms, hornworms, and the tobacco budworm are the more important insects attacking tobacco. They are generally widespread and must be contended with in practically all tobacco production areas.

Social Factors. Tobacco is well adapted to a tenancy system because it is a cash crop of high acre value, requiring much hand labor but little machinery. Most of the tobacco farms are operated by the owners in the northern tobacco producing areas, but in other sections probably as much as half of the total production is under some form of tenancy. In some sections the tenant furnishes everything but the real estate; in others the tenant is simply a "cropper" growing only tobacco.

52. Ibid, p. 22.
IV. Irish or White Potato.

A large part of the Irish potato crop is produced in the north-eastern part of the United States. Six states (Maine, New York, Pennsylvania, Michigan, Wisconsin, and Minnesota) produced 46.8% of the 3,678,985,000 bushels of potatoes produced in the United States for the ten year period ending in 1938.

Climatic Adaptations. Potatoes do best in regions where the summer temperatures are relatively low and where the moisture supply is ample and is reasonably well distributed throughout the growing season. Climatic conditions much like this prevail in the above mentioned states.

Smith makes the following statement concerning the production areas of potatoes:

In the United States the potato has made its greatest development in the cooler sections of the country, where the mean annual temperature is between 40 and 50 degrees Fahrenheit and where the mean temperature in July is not over 70 degrees. Further, the greatest yields of potatoes per acre are in those states where the mean annual temperature is below 65 and where the mean of the warmest month is not far from 65.

He further demonstrates the influence of temperature and rainfall upon potato yields by the coefficient of correlation between yields and temperature and between yields and rainfall. Table VII lists the results of the various yield-temperature correlations.

The correlation coefficient for July temperature and potato yields is \(-0.51 \pm 0.07\). Neither of the other months nor the other combinations are as high. July must be the critical month in potato production for the Ohio region.

55. Stuart, Wm., Production of Late or Main Crop Potatoes, U. S. D. A. Farmers' Bulletin No. 1064, p. 2.
TABLE VII.

CORRELATION OF THE MEAN TEMPERATURE FOR DIFFERENT PERIODS, WITH THE POTATO YIELD IN OHIO, 1860 to 1914.

<table>
<thead>
<tr>
<th>Periods</th>
<th>Correlation Coefficient</th>
<th>Probable Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>-0.10</td>
<td>± 0.09</td>
</tr>
<tr>
<td>June</td>
<td>-0.22</td>
<td>± 0.09</td>
</tr>
<tr>
<td>July</td>
<td>-0.61</td>
<td>± 0.07</td>
</tr>
<tr>
<td>August</td>
<td>-0.31</td>
<td>± 0.07</td>
</tr>
<tr>
<td>September</td>
<td>-0.21</td>
<td>± 0.09</td>
</tr>
<tr>
<td>October</td>
<td>-0.11</td>
<td>± 0.09</td>
</tr>
<tr>
<td>June and July Combined</td>
<td>-0.50</td>
<td>± 0.07</td>
</tr>
<tr>
<td>July and August Combined</td>
<td>-0.50</td>
<td>± 0.07</td>
</tr>
<tr>
<td>June, July, and August Combined</td>
<td>-0.49</td>
<td>± 0.07</td>
</tr>
</tbody>
</table>

Source: Ibid, p. 228, Table 3.

July temperature has considerable influence upon potato yields in Tennessee. Table VIII shows the correlation between yields and mean July temperature in Tennessee for the period of 1914 - 1932 to be -0.627 ±.10. Many of the plantings are made at such a time as to result in the formation of tubers during July. One can say with a fair degree of accuracy that the higher the temperature over the optimum condition during the tuber formation stage the lower will be the resulting yield.
# Table VIII.

## Correlation Between the Yield of Potatoes and the Mean July Temperature, in Tennessee

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield per acre of Potatoes</th>
<th>Mean July Temperature</th>
<th>Deviation from Mean of Yield</th>
<th>Deviation from Mean of Temperature</th>
<th>(x^2)</th>
<th>(y^2)</th>
<th>(xy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1914</td>
<td>45</td>
<td>79.4</td>
<td>-34.3</td>
<td>1.3</td>
<td>1176.49</td>
<td>1.69</td>
<td>-44.6</td>
</tr>
<tr>
<td>1915</td>
<td>83</td>
<td>77.0</td>
<td>10.7</td>
<td>-1.1</td>
<td>114.49</td>
<td>1.21</td>
<td>-11.8</td>
</tr>
<tr>
<td>1916</td>
<td>82</td>
<td>77.9</td>
<td>4.7</td>
<td>-0.2</td>
<td>22.09</td>
<td>0.04</td>
<td>-0.9</td>
</tr>
<tr>
<td>1917</td>
<td>94</td>
<td>76.4</td>
<td>16.7</td>
<td>-1.7</td>
<td>278.89</td>
<td>2.39</td>
<td>-23.4</td>
</tr>
<tr>
<td>1918</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1919</td>
<td>67</td>
<td>79.1</td>
<td>-10.3</td>
<td>1.0</td>
<td>106.09</td>
<td>1.00</td>
<td>-10.5</td>
</tr>
<tr>
<td>1920</td>
<td>83</td>
<td>76.3</td>
<td>5.7</td>
<td>-1.5</td>
<td>52.49</td>
<td>2.25</td>
<td>-3.6</td>
</tr>
<tr>
<td>1921</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1922</td>
<td>80</td>
<td>77.4</td>
<td>2.7</td>
<td>-0.7</td>
<td>7.29</td>
<td>0.49</td>
<td>-1.9</td>
</tr>
<tr>
<td>1923</td>
<td>90</td>
<td>77.2</td>
<td>12.7</td>
<td>-0.9</td>
<td>161.29</td>
<td>0.81</td>
<td>-11.4</td>
</tr>
<tr>
<td>1924</td>
<td>80</td>
<td>75.7</td>
<td>2.7</td>
<td>-2.4</td>
<td>7.29</td>
<td>5.76</td>
<td>-6.5</td>
</tr>
<tr>
<td>1925</td>
<td>56</td>
<td>79.1</td>
<td>-21.5</td>
<td>1.0</td>
<td>465.69</td>
<td>1.00</td>
<td>-21.5</td>
</tr>
<tr>
<td>1926</td>
<td>78</td>
<td>77.0</td>
<td>0.7</td>
<td>-1.1</td>
<td>0.49</td>
<td>1.21</td>
<td>-0.9</td>
</tr>
<tr>
<td>1927</td>
<td>88</td>
<td>77.5</td>
<td>10.7</td>
<td>-0.8</td>
<td>114.49</td>
<td>0.84</td>
<td>-8.6</td>
</tr>
<tr>
<td>1928</td>
<td>85</td>
<td>78.3</td>
<td>17.7</td>
<td>0.2</td>
<td>313.29</td>
<td>0.04</td>
<td>3.5</td>
</tr>
<tr>
<td>1929</td>
<td>92</td>
<td>78.0</td>
<td>14.7</td>
<td>-0.1</td>
<td>216.09</td>
<td>0.01</td>
<td>-1.5</td>
</tr>
<tr>
<td>1930</td>
<td>70</td>
<td>81.7</td>
<td>-7.3</td>
<td>3.6</td>
<td>53.29</td>
<td>12.36</td>
<td>-26.3</td>
</tr>
<tr>
<td>1931</td>
<td>59</td>
<td>80.2</td>
<td>-18.5</td>
<td>2.1</td>
<td>354.89</td>
<td>4.41</td>
<td>-33.4</td>
</tr>
<tr>
<td>1932</td>
<td>69</td>
<td>80.1</td>
<td>-8.5</td>
<td>2.0</td>
<td>65.89</td>
<td>4.00</td>
<td>-16.6</td>
</tr>
</tbody>
</table>

**Correlation Coefficient = \(-0.627 \pm 0.103\)**


3. The Pearsonian Coefficient of Correlation formula was used to compute this figure.
The correlation coefficient cannot be pointed to as being an absolute measure of the exact influence of temperature because such variables as moisture, insect damage and lateness of the season are not held constant. They may tend to increase the apparent temperature coefficient or they may lower it. The correlation coefficient of yields to July precipitation, shown by Table IX to be \( .252 \pm .227 \), is low enough to be insignificant by itself; yet it is valuable as an indicator of the apparent value of the temperature correlation. One can say with a fair degree of certainty that July temperature is a much greater limiting factor in Tennessee than is July precipitation.

Smith found that July precipitation in Ohio had a somewhat greater influence than that for Tennessee. (See Table X)

Evidently the influence of temperature is greater and that of moisture is less in Tennessee than in Ohio. Higher temperatures are less ideal and higher rainfall is more ideal. This situation substantiates an earlier statement that as the distance from the optimum condition of a limiting factor increases, its influence as a limiting force tends to increase.
Table IX.

CORRELATION BETWEEN THE YIELD OF POTATOES AND THE JULY PRECIPITATION, IN TENNESSEE

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield per acre of Potatoes</th>
<th>July Precipitation</th>
<th>Deviation from Mean of yield</th>
<th>Deviation from Mean of Precipitation</th>
<th>$x^2$</th>
<th>$y^2$</th>
<th>$xy$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1914</td>
<td>48</td>
<td>4.34</td>
<td>-34.3</td>
<td>0.03</td>
<td>1176.49</td>
<td>0.001</td>
<td>-1.03</td>
</tr>
<tr>
<td>1915</td>
<td>88</td>
<td>4.56</td>
<td>10.7</td>
<td>0.05</td>
<td>114.49</td>
<td>0.002</td>
<td>0.54</td>
</tr>
<tr>
<td>1916</td>
<td>82</td>
<td>7.30</td>
<td>4.7</td>
<td>2.99</td>
<td>22.09</td>
<td>8.940</td>
<td>14.06</td>
</tr>
<tr>
<td>1917</td>
<td>94</td>
<td>6.77</td>
<td>16.7</td>
<td>2.36</td>
<td>278.59</td>
<td>5.570</td>
<td>39.61</td>
</tr>
<tr>
<td>1918</td>
<td>67</td>
<td>2.64</td>
<td>10.3</td>
<td>-1.67</td>
<td>106.09</td>
<td>2.789</td>
<td>17.20</td>
</tr>
<tr>
<td>1919</td>
<td>83</td>
<td>3.83</td>
<td>5.7</td>
<td>-0.48</td>
<td>32.49</td>
<td>0.230</td>
<td>-2.74</td>
</tr>
<tr>
<td>1920</td>
<td>80</td>
<td>5.58</td>
<td>2.7</td>
<td>1.27</td>
<td>7.29</td>
<td>1.613</td>
<td>3.43</td>
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<tr>
<td>1922</td>
<td>90</td>
<td>5.99</td>
<td>12.7</td>
<td>-0.32</td>
<td>161.29</td>
<td>0.102</td>
<td>-4.66</td>
</tr>
<tr>
<td>1924</td>
<td>80</td>
<td>5.81</td>
<td>2.7</td>
<td>-0.50</td>
<td>7.29</td>
<td>0.026</td>
<td>-1.35</td>
</tr>
<tr>
<td>1925</td>
<td>55</td>
<td>3.34</td>
<td>-21.3</td>
<td>-0.97</td>
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<td>1926</td>
<td>78</td>
<td>3.36</td>
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<td>-0.95</td>
<td>0.49</td>
<td>0.903</td>
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<tr>
<td>1927</td>
<td>88</td>
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<td>-0.30</td>
<td>114.49</td>
<td>0.090</td>
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<td>95</td>
<td>3.57</td>
<td>17.7</td>
<td>-0.74</td>
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<td>1929</td>
<td>92</td>
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<td>216.09</td>
<td>0.012</td>
<td>1.62</td>
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<tr>
<td>1930</td>
<td>70</td>
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</tr>
<tr>
<td>1931</td>
<td>59</td>
<td>4.32</td>
<td>-18.5</td>
<td>0.51</td>
<td>354.89</td>
<td>0.260</td>
<td>-9.35</td>
</tr>
<tr>
<td>1932</td>
<td>69</td>
<td>4.80</td>
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<td>0.49</td>
<td>68.89</td>
<td>0.240</td>
<td>-4.07</td>
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<tr>
<td></td>
<td>77.3</td>
<td>4.31</td>
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<td></td>
<td>3461.53</td>
<td>23.069</td>
<td>71.59</td>
</tr>
</tbody>
</table>

Correlation coefficient $= 0.252 \pm 0.227^3$

3. The Pearsonian coefficient of correlation formula was used to compute this figure.
<table>
<thead>
<tr>
<th>Period</th>
<th>Correlation Coefficient</th>
<th>Probable Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>-0.21</td>
<td>± 0.09</td>
</tr>
<tr>
<td>May</td>
<td>0.06</td>
<td>± 0.10</td>
</tr>
<tr>
<td>June</td>
<td>0.10</td>
<td>± 0.09</td>
</tr>
<tr>
<td>July</td>
<td>0.33</td>
<td>± 0.09</td>
</tr>
<tr>
<td>August</td>
<td>0.22</td>
<td>± 0.09</td>
</tr>
<tr>
<td>September</td>
<td>-0.13</td>
<td>± 0.09</td>
</tr>
<tr>
<td>October</td>
<td>0.07</td>
<td>± 0.10</td>
</tr>
<tr>
<td>July and August Combined</td>
<td>0.37</td>
<td>± 0.08</td>
</tr>
</tbody>
</table>


A quick and healthy growth of the plant and a steady and uniform growth of the tubers make essential a goodly supply of moisture. A rainfall of approximately 12 to nearly 18 inches between the date of planting and the harvesting time is to be found in the leading potato growing regions. It is possible, however, that the heavier precipitation mentioned above might be so unevenly distributed that high yields would be impossible.57

57. Stuart, Wm., The Potato, p. 21.
High rates of precipitation help to offset the damage of high temperatures because of the cooling effect to the soil that results from the evaporation of water. But another factor has a counterbalancing effect. A combination of high temperatures and high soil moisture content makes the potato plant more susceptible to disease attacks. Table XI shows the results secured in a controlled greenhouse study. Fusarium was much more prevalent under warm, moist conditions.

Tuber formation stops when the soil gets too hot. Figures 36 and 37 show the result of heat and drought upon Green Mountain and Irish Cobbler potatoes respectively. Both varieties are grown in Tennessee and similar results are to be expected if the potato producer attempts to grow his crop during the hot summer months.

The average mean temperature in Tennessee is 58.7 degrees for April, 66.4 degrees for May, 74.4 degrees for June, 77.5 degrees for July, 78.3 degrees for August, 71.3 degrees for September, and 59.6 degrees for October. Plantings made resulting in tuber formation during the hot months will be disappointing. If the production is to be economically increased this period must be avoided.

One method of avoiding the high summer temperature is to plant the crop early enough for it to mature before the hot weather starts or to plant it late enough to permit the crop to mature during the cool, fall months. Regions with sufficiently long periods of moderately cool, moist weather either in the spring or in the fall may avoid high summer temperatures in this manner, but difficulty often arises from the fact that

58. Drain, Brooks D., Personal Interview.
59. U. S. D. A., Weather Bureau, Summary of the Climatological Data for the United States by Sections, Reprint of Section 77 - Middle West Tennessee, and Reprint of Section 78 - East Tennessee and Western North Carolina.
### Table XI.

**INFLUENCE OF PERCENTAGES OF WATER IN SOIL AND TEMPERATURES OF SOIL UPON THE DISEASE RESISTANCE OF POTATO PLANTS**

<table>
<thead>
<tr>
<th>Water %</th>
<th>Soil Temp °F</th>
<th>Disease Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% 65</td>
<td>20% 65</td>
<td>20% 65</td>
</tr>
<tr>
<td>10% 65</td>
<td>20% 80</td>
<td>20% 80</td>
</tr>
<tr>
<td>10% 50</td>
<td>20% 95</td>
<td>20% 50</td>
</tr>
<tr>
<td>10% 65</td>
<td>20% 95</td>
<td>20% 65</td>
</tr>
<tr>
<td>10% 50</td>
<td>20% 95</td>
<td>20% 80</td>
</tr>
<tr>
<td>10% 50</td>
<td>Flooded twice</td>
<td>50</td>
</tr>
</tbody>
</table>

Source: Fitch, C. L., Studies of Health in Potatoes, Colorado Bulletin No. 216, Figure 12, p. 20.

Summary of greenhouse studies of potato health. Percentages of water in soil and temperatures of soil for first 75 days shown above the line, and for the next five days shown below the line in the form of a fraction in each case. Presence of disease is shown by a plus (+) sign and absence of disease, by a minus (−) sign.
early spring seedlings may be impossible because of prolonged wet weather which leaves the ground too wet and cold for proper seed bed preparation and for planting the crop. Hot, droughty spells in late summer also may prohibit plantings for fall maturity in regions where they prevail.

Figure 36. Environmental influence on form of tuber of Green Mountain Variety. Tubers 1, 2, 5, and 6, very much modified; 3 and 4 true to type. Modification due to heat and drought. Tubers produced from the same strain of seed.
Source: Stuart, Wm., The Potato, Figure 3, p. 16.

Figure 37. Environmental influence on form of tuber of Irish Cobbler Variety. Tubers 1 and 2 very much modified, 3 and 4 true to type. Modification due to heat and drought. Sources of seed identical.
Source: Stuart, Wm., The Potato, Figure 4, p. 17.
Soil Requirements. Generally speaking the best potato soils are the sandy, gravelly, or shaly loam soils, and the poorest are the heavy, sticky clays or the very light sandy soils. A loose friable soil that is well supplied with organic matter, that is deep and well drained, and that is sufficiently supplied with moisture from natural or artificial sources to insure the production of a good crop is desired.

Economic Factors. Economic factors, such as closeness to the market, are largely responsible for the regions near the cities where potatoes are produced in spite of the existing soil or climatic conditions. Potatoes are bulky in proportion to their unit value, consequently they will be produced relatively close to the centers of population.

Potatoes furnish a moderately intensive crop that can be grown in relatively small fields. A man can care for close to three acres quite well without special equipment such as planters and diggers. Furthermore, the larger returns per acre and the more intensive cultural practices make small, odd-shaped fields less undesirable than they would be for corn and the small grains.

The potato is an intertilled crop grown principally as a cash crop or for home consumption. It must compete with such crops as corn, tobacco, and cotton for a place in the rotation, for labor and power, and for farming equipment; and if these crops can be successfully grown they usually have prior claim to the land. It happens, however, that potatoes are not generally adapted to the same physical conditions as these other crops. It is grown where the mean temperature is too low, where the growing season is too short, or where the soil is too light for these other crops.

Potatoes can be used as a crop to plant between the rows of trees in orchards better than most crops. The use of nitrate fertilizers on the potatoes greatly offsets any objectionable feature that may be connected with the practice, for the trees may use a part of the nitrates thus supplied. A crop that completely covers the ground might be more satisfactory in badly eroding orchards.

Potato Diseases. The potato is susceptible to the attack of many diseases that cause more or less severe injury to the plant itself and to its resultant tubers. A number of obscure maladies affecting the potato as yet cannot be classed with certainty as pathological diseases caused by parasitic organisms. Such maladies, however, shall all be considered as true diseases in the following discussion. Many of the more important diseases are quite general in their environmental requirements; only those with definite territorial adaptations will be considered.

Late blight is confined rather closely to the North temperate zone, including the whole northeastern portion of the United States and the adjoining part of Canada. The disease has been fairly prevalent in the Pacific Coast sections of Oregon and Washington. Occurrences, though hardly in epidemic form, have been noted along the whole Atlantic Coastal Plain, but there is little injury south of Maryland because the early crop is harvested before the disease has much opportunity to infest the plant. The late crop of this latter section is rarely damaged because the climatic conditions are unfavorable to the disease. 62

Fusarium wilt is regional rather than general in its occurrence in that it is serious only in Minnesota, North Dakota, Nebraska, Utah, Arizona, California, New York, and the New England States. There is, however, a more or less general prevalence from New York west to the Pacific Coast. 63

Common scab organisms, perhaps the most widely distributed of the potato diseases, may be present in absolutely virgin soil rather far removed from that under cultivation. It is so common that it may be said to occur almost everywhere the potato is grown. Any potato producing area, therefore, may expect to have to contend with disease. A soil with an alkaline reaction is much more likely to be infected with scab than one that is slightly acid. Heavy applications of manure furnish excellent growing media for the scab organism. 64

The potato wart disease has been discovered in only a few mining towns of Pennsylvania, West Virginia, and Maryland. 65 Blackleg is rather widely distributed in the potato-growing sections of the Northeastern United States. Favorable conditions are continued wet, cloudy weather and a naturally moist soil. 66 The occurrence of bacterial wilt is confined to the Southern States. Losses may be reduced by a rotation of crops, soil sanitation, and good drainage and aeration. 67 Leaf-roll is more or less general in Northeastern United States and Canada, and it may be found in scattered areas throughout the western potato fields. 68

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63. Ibid, p. 256.
64. Ibid, pp. 265 - 267.
65. Ibid, p. 269.
67. Ibid, p. 274.
68. Ibid, p. 276.
Probably no other disease, except possibly the potato wart, has caused more widespread alarm as to the dire injury it might cause to the potato crop than has the powdery scab. Upon becoming more closely acquainted with this disease, it was discovered that it thrives only under exceptionally favorable environmental conditions. It will not thrive in warm regions. Even when scab-infected and untreated seed are planted in the South, one can expect that there will be no evidence of powdery scab infection.

Curly-dwarf is much more prevalent in the northeastern part of the United States than in the remainder of the country. It has been rarely noted in the western states. Tip-burn, a purely physiological trouble, is caused by the failure of the root hairs of the potato plant to furnish a sufficient supply of moisture to the leaves during hot, dry, windy, and sunshiny days, when the rate of moisture transpiration from the leaves is greater than the rate of supply. Areas where such climatic conditions exist can expect considerable loss from tip-burn if potato production is attempted.

Insect Pests. Many insects attack the potato plant, but the more common ones are generally widespread throughout all potato producing areas. The Colorado Potato Beetle, potato flea beetle, three-lined potato beetle, tortoise beetle, blister beetles, potato stalk and stem borers, potato stalk weevil, cutworms, white grubs, potato aphids, and potato leafhoppers are the worst insect pests common to most potato regions. The potato tuber moth does its greatest damage in California, Texas, Florida, North and South Carolina, and Virginia.
Social Factors. Many regions are producing large quantities of potatoes not because they have any especially favorable physical factors but because of the nationality of the people in these regions. People in German and Scandinavian settlements often produce large quantities of potatoes because that is a crop their families have been producing for centuries. They know how to and like to raise potatoes, but they may not know how to produce many of the other field crops. Furthermore, these thrifty people are not afraid to work and do not discriminate against the crop because it has considerable rather menial hand labor connected with its culture.

V. Sweetpotato.

The sweetpotato is of great importance as a commercial crop in the southeastern part of the United States where it is one of the principal vegetable foods of the people. Commercial sweetpotato production demands that careful consideration be given to the soil and climate and to market, transportation, and storage facilities. A much wider range of conditions is favorable to the production of the crop for home use. The season through which sweetpotatoes are available on the markets has been greatly lengthened by the development of the sweetpotato storage house.

Climatic Adaptations. As it is a native of tropical America, the sweetpotato naturally thrives better in the warmer portions of the United States than in other parts of the country. The heaviest production areas,
as shown by Figure 38, extend from New Jersey southward and westward to Texas; there are also two production areas in California. Sweetpotatoes are best suited to a climate that has a growing season of at least four months. This period should have a moderate rainfall, warm nights, and plenty of sunshine. Considerable success has been attained with irrigation in regions where the rainfall is very light. 73

![Map of United States showing sweetpotato growing areas.](image)

Figure 38. Areas in the United States in which sweetpotatoes are grown.
Source: Miller, F. E., Beattie, J. H., and Zimmerley, H. H., 
Sweetpotato Growing, U. S. D. A. Farmers' Bulletin No. 999, 
Figure 1, p. 2.

A heavy rainfall during the late spring and summer insures vigorously growing plants and the formation of an abundant and well shaped tuber crop, but as the harvest season approaches considerably less rain is needed. Much rain immediately before and during harvest may result in a considerable loss because of injury to the flavor of the potato; its keeping and shipping qualities are also greatly impaired. Growers along the Atlantic and Gulf Coasts have often suffered great losses from an unusually long continued

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73. Ibid, p. 2.
spell of wet weather that has caused the entire crop to rot in the field. More often such weather causes a souring of the potato which makes it easily susceptible to disease attack on the slightest bruising thus rendering it practically impossible of successful storage. A dry season followed by late rains, even though not excessive, tends to cause a second growth of the tubers which causes excess sappiness and makes handling in transit more difficult. Harvesting is made tedious by severe droughts late in the season.74

The sweetpotato is strictly a summer crop that grows best in the hottest part of the year. Maximum yields can be expected when the temperature during the summer growing season ranges from 70 to 100 degrees Fahrenheit. Growth is noticeably checked by cool weather, and the crop is exceedingly sensitive to frost.75

Soil Requirements. The ideal sweetpotato soil is a light, well-drained sandy loam with a clay subsoil. The crop can be grown on a wide range of soils if the growing season is sufficiently long. Sweetpotatoes can be grown successfully on almost pure sands if a reasonable quantity of commercial fertilizer is applied. The crop tends to run to vines at the expense of the roots on very fertile soils; furthermore, the market value of the potatoes is reduced because they tend to be rough and irregular in appearance. If a good rotation is followed and a legume green manure is turned under, fair yields can be obtained when the crop is grown on worn-out cotton and tobacco lands in the South. Soils lacking in fertility need a moderate quantity of organic matter in the soil for the best results in growing sweetpotatoes.76

75. Ibid, p. 17.
Newly cleared lands, such as the cut-over pinelands of the South, grow particularly good crops of sweetpotatoes. It is better, however, to put sweetpotatoes on the land the second year and to grow some crop such as corn the first year. The roots of trees and shrubs interfere with cultivating and harvesting the sweetpotatoes on land that has been recently cleared.

Sweetpotatoes do best on well drained soils; they should never be planted on any soil unless it is fairly well drained, and even then in most cases they should be planted on ridges to keep the surface water from standing around the plants. A surface soil that is 6 to 8 inches in depth and that is underlain with a clay subsoil porous enough to carry off the surplus water and yet of such a nature as to prevent fertilizers from leaching away gives the best results. Long stringy roots which are unfit for market are produced on a deep surface soil with a sandy or very porous subsoil. A surface soil that is too shallow should be either avoided or deepened each year by gradually increasing the depth of plowing until the desired depth is reached.

Economic Factors. There is a large potential market for the sweetpotato in many sections of the Northern and Western parts of the United States; the people in many of these sections have not become accustomed to using them, but the southern and many of the eastern markets usually are well supplied with sweetpotatoes. Better storage and marketing facilities have made it possible to ship sweetpotatoes to distant markets whenever the price permits. Extremely long shipments, however, are rarely possible because of the bulky nature of the product in relation to its unit value.

77. Ibid, p. 3.
78. Ibid, p. 3.
A production area should have access to a local storage house.

The sweetpotato has much the same set of adaptations to the economic organization of the farm business as does the Irish potato. It is a moderately intensive intertilled cash crop that returns quite large quantities of marketable product per acre. The crop is reasonably well adapted either to hand operations or to large scale machine operations. It differs from the Irish potato in the time when it shall be planted and harvested; it is later because it is primarily a warm season crop. Much hand labor is required during the transplanting season.

Biological Factors. A number of diseases attack the sweetpotato either when it is a young plant in the hotbed, a growing crop in the field, or a finished product in storage. Most of these diseases, such as stem rot and black rot, are prevalent throughout the sweetpotato producing regions. The most severe damage done by foot rot is found in Virginia, Iowa, and Missouri. Root rot, a disease prevalent in the Southwest, is worse on heavy soils than on light well-drained ones. It is particularly hard to control because it has a large number of host plants. Scurf is worse on heavy soils, especially those containing large quantities of organic matter. Leaf-blight rarely occurs on the east coast north of Virginia or in the states of Iowa, Illinois, and Kansas; it is principally a disease of the South. White-rust is favored by frequent rains and heavy dews combined with high temperatures. Soft rot occurs when the crop is planted on heavy poorly drained soils.

The sweetpotato is not seriously attacked by many insects. Each different section of the country has its specific insect pests, but the

South must contend with a far greater number and must withstand much more material damage than the East and the Midwest. The most serious insect pest of sweetpotatoes is the sweetpotato weevil. It is quite prevalent in the Gulf States. Texas, the state where it is probably worst, had a loss of 20% of the 1917 crop, which amounted to about $1,800,000 from the attack of this insect.

VI. Broomcorn.

Broomcorn, a sorghum that produces heads having long branches which form a brush, is used almost exclusively for making brooms and whisk brooms. It was first grown commercially in the Connecticut Valley in Massachusetts; from there it has advanced westward with successive centers of production in the Mohawk Valley of New York, the Scioto Valley of Ohio, eastcentral Illinois, the Smoky and Arkansas Valleys of Kansas, the Washita Valley of Oklahoma, and the section comprising southwestern Kansas, northwestern Oklahoma, and the adjoining areas of Colorado and New Mexico. It was formerly grown rather extensively in Virginia, Tennessee, Missouri, Iowa, and Nebraska. This westward movement of the production areas represents a shift to cheaper lands.

Climatic and Soil Requirements. Some broomcorn is grown in practically every state in the United States. A fair quality brush can be produced wherever the temperatures are high enough for corn grown for grain to do well. It is not grown successfully in the extreme Northern and Northwestern States where the temperatures usually are too low. The crop is a heat

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loving plant that produces the best brush in regions where the summers are rather warm and where soils are fertile and fairly well supplied with moisture. A higher yield and quality of brush is produced on deep alluvial soils than on the shallower soils of the uplands, consequently much of the broomcorn of the past was grown on rich river-bottom land. Only an inferior brush can be expected from poor soils and cold or extremely dry weather.

**Economic Factors.** It is possible to grow broomcorn in many localities where it is not grown except on a small scale for local consumption; its production on a wide scale is prevented by the limited demand for the crop. Potential production areas which have practically ideal soil and climatic conditions generally will find it unprofitable to reduce their production of the staple commodities, such as corn and cotton, in favor of broomcorn. These crops are threatened much less with extreme losses from overproduction.

Broomcorn is relatively non-bulky in the baled form, consequently it may be shipped long distances readily.

Broomcorn is suited to extensive operations up to harvest time. Seed bed preparation, planting, and cultivation can be carried on quite easily with large team and tractor units. The harvesting process, however, requires a large quantity of hand labor for a relatively few days. It takes one man from 15 to 25 hours to table and cut an acre of broomcorn.

The extremely seasonal nature of this large labor requirement makes necessary the availability of relatively cheap labor in large quantities in August and September. This labor supply may be drawn from local farms.

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84. Ibid, p. 3.
in communities where the broomcorn acreage is not too concentrated. Normally, however, broomcorn regions must depend upon transient labor during the harvesting season.

Broomcorn is an intertilled cash crop, consequently it occupies much the same place in a rotation as does corn or cotton. The general labor and equipment requirements are very little different except those needed for harvesting purposes. Large sheds equipped with slats are necessary for the drying and curing of the heads in the more moist regions. The open nature of these sheds makes them undesirable for any other productive use. Special threshers and balers must be available within the community.

The tables of broken stalks are quite difficult to handle in preparing the land for the next crop. They are extremely hard to plow under while still in the table form. Some people attempt to burn them if a time can be found when they are dry enough to burn. The loss of fertility is usually counterbalanced by a greatly reduced amount of trouble and time necessary for plowing the field.

Biological Factors. Broomcorn is attacked by the same diseases and insects that attack the sorghums and Indian corn. These pests will influence the production areas of broomcorn in much the same manner.
Sugarcane is not a sorghum. It is grown in the United States chiefly as a sirup crop; some cane grown in Louisiana is manufactured into sugar.

**Climatic Adaptations.** A growing period of eight months or more of warm growing weather with plenty of moisture is required by sugarcane. The only parts of the United States in which it can be successfully grown are the warmer parts of the country, including the extreme southern part of South Carolina, all of Florida, the southern third of Georgia, Alabama, and Mississippi, the southern half of Louisiana, and the low Coastal Plains of Texas. It probably could be grown under cultivation in the lower lying valleys of southwestern Arizona and southern California, but it has not been tested extensively in these regions yet.

**Soil Requirements.** Heavy demands upon the soil for moisture and plant food are made by sugarcane. Sandy soils are not desirable because the expense of keeping up the fertility is prohibitive, and the crops suffer quickly and seriously from drought. Heavy clay soils will not dry out and warm up early enough in the spring, and they cannot be kept in as good tilth as is required by the crop. Sandy soils which contain either a high percentage of silt and clay or a liberal supply of organic matter which will enable the soil to retain moisture and plant food may be used, but the soils of the humus-sand combination are likely to become unfit for this crop because of the rapid depletion of the organic matter. The value of the cane crop ordinarily will not justify the use of the expensive means of replenishing organic matter which are necessary on such soils. A clay

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soil, on the other hand, must contain enough silt or sand to provide it with good tilth and to insure that it will warm up early in the spring. 87

Large yields of cane, which are likely to have a low sugar content, can be expected on muck soils if they have a high mineral content and are well drained. Any muck land, however, has a disadvantage in that it affords such poor anchorage for the roots that the cane lodges easily. It has been reported in Georgia that the rich dark soils along the edges of swamps, while producing high yields of cane, have a deleterious effect upon the color, clearness, and flavor of the sirup from such cane. The ground water level should be at least three feet below the surface. 88

Economic Factors. Sugar cane is an intertilled crop that may be marketed either before or after it is made into sirup. When the latter process is used it is necessary for each farmer or small community to have a sirup-making outfit, and when the former process is used the mill must be within economical hauling distance.

There is considerable hand labor connected with the production of sugar cane. Without considering the labor needed to grind the cane and to boil the sirup, over 22 days of labor are necessary to produce an acre of sugar cane; approximately 10 more are needed for the grinding and boiling processes. 89 Much of this labor comes during the harvesting season. Large quantities of cheap labor are necessary in a community if it is going to produce sugar cane economically. The labor demands will interfere considerably with those for cotton, consequently the two crops do not fit readily into the same rotation.

88. Ibid, pp. 9-10.
89. Ibid, p. 32.
Biological Factors. Only two insect pests, the moth borer and the mealy bug, seriously damage the sugar cane crop. They are widely prevalent in most tropical cane countries, and both do considerable damage in Louisiana. The moth borer is established also in the Rio Grande section of Texas and in portions of central and eastern parts of Florida.

Red-rot is the disease that has caused by far the greatest damage to the cane crop in the United States. It is distributed throughout most of the regions where the crop is grown extensively. Other diseases which cause some damage are the root-rot and the mosaic disease; both seem to be generally adapted to all cane areas.

VIII. Sugar Beets.

The sugar beet, a crop grown primarily for the sugar that is extracted from its root, may be grown under very different conditions in a wide range of territory. Because of the expense incident to the production of this intensive crop, the yields must be sufficiently high for the crop to compete successfully with the other crops grown, and the sucrose content must be sufficient to permit the profitable manufacture of sugar if it is to be successfully produced.

Climatic Adaptations. The sugar beet requires an adequate supply of moisture that will insure a continuous and rapid growth during the growing season. A long and moderately cool growing season also favors the best growth of the plant. Ideal temperature conditions are those where the mean

summer temperature (May to September inclusive) is between 67 and 72 degrees Fahrenheit. Warm days and fairly cool nights during the growing season favors the rapid growth of the crop. Growth of the root will continue as long as the temperature and moisture conditions are favorable, consequently a longer period of favorable conditions means a greater tonnage per acre. The storage of sucrose is not favorably influenced by conditions that permit a continuation of vegetative growth, and as the value of the crop depends upon its sucrose content, it is desirable to have the vegetative growth of the root retarded. Fall days which are warm and sunny and nights which are becoming cooler, combined with a decreased moisture supply, will retard the vegetative growth (but it must not be completely stopped) and accelerate the storage of sucrose in the root.  

**Soil Requirements.** Sugar beets have a very wide adaptation of soil types, and they may be grown upon either mineral or organic soils. The heavier types of soils, such as the loams, silt loams, clay loams, and clays, are generally better suited to sugar beet production than are the lighter soils such as sands and sandy loams. The ideal sugar beet soil, besides having the desired soil type, is one which has good depth, a fairly high organic content, adequate drainage, high moisture-holding capacity, and a favorable reaction.

The soil should have a depth of at least three feet before there is any change in structure that prevents the penetration of the roots. Such obstructions as hardpan, plow-sole, or a high water table will cause ill-

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93. Ibid., pp. 2 - 3.
94. Ibid., pp. 3 - 4.
shaped roots. Mineral soils give better results when they contain a fairly high content of organic matter which is valuable as a source of some of the plant food elements, as a great factor in the retention of moisture, and in influencing the state of tilth of the soil. The lack of drainage limits the depth of root penetration with a resultant poorer quality root and a limit of the volume of soil upon which the crop can draw for the mineral and moisture supply for its growth. The soil reaction should be slightly alkaline for the best results with sugar beets, but satisfactory yields are often obtained on soils with a slightly acid or even an acid reaction. 95

Economic Factors. Sugar beets occupy much the same place in a farm system as does any other intertilled cash crop. Seedbed preparation, planting, and cultivating are similar to the corresponding operations for the other intertilled crops. Large units of power may be employed to a good advantage. Blocking and thinning as well as harvesting require considerable hand labor.

The sugar beet is a very bulky product that can be economically hauled only a few miles to a factory. This necessitates the presence of a beet-sugar factory in every community that produces the crop.

The demand for beet sugar is not exceedingly great. There is some danger of over-production, consequently areas favorable to sugar beets but equally favorable to corn or some other crop often do not produce the sugar beet because of this danger of loss from overproduction. Over a period of time the staple crops are much more satisfactory if they can be grown.

95. Ibid. pp. 4 - 7.
Biological Factors. Of the various diseases which attack the foliage of the sugar beet, only one, the leaf spot, causes any appreciable damage. It thrives under warm, highly humid conditions. There are also several seedling diseases and root rot that cause considerable trouble, but they are present in practically all soils of humid regions. Poor drainage, poor soil aeration, and other factors unfavorable to the plant are favorable to the development of the diseases.

There are no insects which cause wide-spread damage to the sugar beet crop. Cutworms, white grubs, wireworms, flea beetles, and grasshoppers all have been known to cause severe local damage.

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97. Ibid, p. 27.
Other Field Crops. (Chapter V)


Collings, G. H., The Production of Cotton, John Wiley and Sons, New York, 1926.

Drain, Brooks D., Personal Interview.


Fitch, C. L., Studies of Health in Potatoes, Agricultural Experiment Station of the Colorado Agricultural College, Fort Collins, 1915.


Posey, W. B., *Tobacco Culture in Maryland*, University of Maryland, Extension Service, College Park, Maryland, 1932.


CHAPTER VI.

LIVESTOCK

1. Introduction.

The factors determining livestock production areas may be of a primary or a secondary nature. Those directly influencing the production of livestock, such as water and feed supply, markets, and climate are the primary factors; the secondary factors are those that primarily influence the production of crops which are to be marketed through livestock or which are competitive with the crops grown for livestock consumption.

Influences of Density of Population. One of the most important factors influencing the production areas of livestock is the matter of relative efficiency of the product being considered. thinly populated regions tend to produce commodities of a more extensive nature than those where the population is considerably more dense. As the population per acre increases, those livestock and crop enterprises with the higher per acre returns of human food will be grown. There is a constant shifting of production areas in a newly settled country such as the United States. The more intensive enterprises keep pushing the extensive commodities into the less densely settled areas.

Table XII shows the amount of food produced annually by an acre of land when utilized in the production of various food crops and livestock products. Note that the amount of human food produced per acre by food crops is far greater than that of livestock. Only the most intensive and the most essential livestock enterprises will be found where the population is exceedingly dense.
Table XII.

HUMAN FOOD PRODUCED ANNUALLY FROM AN ACRE OF LAND UTILIZED AS VARIOUS FOOD PRODUCTS

<table>
<thead>
<tr>
<th>Food Product</th>
<th>Yield per Acre</th>
<th>Human Food per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bushels</td>
<td>Pounds</td>
</tr>
<tr>
<td><strong>Food Crops:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>35</td>
<td>1,960</td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td>110</td>
<td>5,940</td>
</tr>
<tr>
<td>Irish potatoes</td>
<td>100</td>
<td>6,000</td>
</tr>
<tr>
<td>Rye</td>
<td>20</td>
<td>1,200</td>
</tr>
<tr>
<td>Wheat</td>
<td>20</td>
<td>1,200</td>
</tr>
<tr>
<td>Rice (polished)</td>
<td>40</td>
<td>1,086</td>
</tr>
<tr>
<td>Soybeans</td>
<td>16</td>
<td>960</td>
</tr>
<tr>
<td>Peanuts</td>
<td>34</td>
<td>524</td>
</tr>
<tr>
<td>Oats</td>
<td>35</td>
<td>754</td>
</tr>
<tr>
<td>Beans</td>
<td>14</td>
<td>840</td>
</tr>
<tr>
<td>Cowpeas</td>
<td>10</td>
<td>600</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>24</td>
<td>600</td>
</tr>
<tr>
<td><strong>Dairy Products:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>2,190</td>
<td>72.3</td>
</tr>
<tr>
<td>Cheese</td>
<td>219</td>
<td>56.7</td>
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<tr>
<td>Butterfat</td>
<td>98.55</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Meat:</strong></td>
<td></td>
<td>Live (Pounds)</td>
</tr>
<tr>
<td>Pork</td>
<td>350</td>
<td>273</td>
</tr>
<tr>
<td>Mutton</td>
<td>205</td>
<td>113</td>
</tr>
<tr>
<td>Beef</td>
<td>216</td>
<td>125</td>
</tr>
<tr>
<td><strong>Poultry:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td>103</td>
<td>66</td>
</tr>
<tr>
<td>Eggs</td>
<td>73.8</td>
<td>110.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Cooper, Morton C. and Spillman, W. J., Human Food From an Acre of Staple Farm Products, U. S. D. A. Farmers' Bulletin No. 877, Table I, p. 4.
Intense competition for the land will force out the products which make the least efficient use of the land in the production of human food. Therefore, as a given region becomes more thickly populated, the more efficient forms of livestock tend to replace the less efficient ones, and finally the efficient forms of livestock tend to give way to the crops directly consumed as human food.

**Physical Factors.** The physical factors such as climate, soil types, and topography affect livestock production both directly and indirectly. All living things must have favorable temperatures and a supply of moisture. Animals of economic importance usually do better in temperate regions than they do when the prevailing mean temperature is near one extreme or the other. Furthermore, it is more economical to produce livestock in regions where they can harvest their own feed for a large part of the year and where shelter expenses are not exceedingly high. Regions with good pasture for long seasons have a distinct advantage over those where the animals must be hand fed from feed made expensive by harvesting and storing for several months. It is natural to expect livestock production in regions where the climatic conditions favor the production of crops suited for livestock feed. There must be an ample supply of clean, healthy water.

Soil type, through its influence upon the crops produced in a given region, also affects livestock production. Another factor often present but more difficult to visualize is the specific influence of soil type upon livestock when the same crops are grown upon the differing types. Animals need considerable calcium, phosphate, and other minerals, consequently crops grown on soils rich in these minerals will
make better livestock feed than those grown elsewhere.

Topography likewise affects livestock production areas both directly and through the crops grown. Some animals thrive in exceedingly rough regions; others will not do well in low lands. The better drainage found on rolling land makes such land more ideal because of the prevalence of diseases, insects, and other parasitic disturbances on poorly drained soils. Land that has considerable slope to it normally should be kept (at least part of the time) in some nontillable crop that may be readily harvested by livestock. The solving of erosion problems normally necessitates the introduction into a cropping system of crops suited to livestock production. Areas too hilly and rough for farming with tilled crops may be utilized as permanent pastures.

Economic Factors. Livestock furnish cheap means of transporting bulky feeds to the consuming centers of the world. The average farmer will feed about 500 pounds of corn for each 100 pounds of live pork produced. It is quite logical to expect that the transportation costs from the production areas to the population centers will be much less on the pork than on the corn. Livestock furnish, therefore, a means of concentrating bulky products into a form upon which the transportation costs will make up a much smaller part of the cost of the product to the consumer.

Whole milk, however, is an exception to this general factor. One hundred pounds of feed fed to high producing cows will produce more than an equal weight of milk because of the water it contains. Milk is much more valuable per unit of weight than is the feed from which it was made, consequently relative transportation costs are less per unit of
Livestock furnishes the farmer a means of expanding his operations. Unmarketable feeds and idle labor may be more fully utilized. The feeding of grain crops on the farm results in a conservation of soil fertility through the manure produced. Legume crops are more likely to be found on livestock farms.

II. Beef Cattle.

Beef Cattle production may be divided into several distinct steps or phases the more important of which are: (1) breeding and rearing calves, (2) growing of stockers, (3) fattening cattle for market, (4) baby beef production, (5) dual-purpose cattle, and (6) breeding purebred cattle. It is possible that all of these phases may be carried out as successive steps of a continuous process on a single farm, but more often, however, one or two are carried on to the exclusion of the others, not only as regards individual farms, but also as regards agricultural regions. The beef animal is used primarily to convert rough, cheap forages unsuited for human consumption into a palatable food.

Breeding and Rearing Calves. Beef cow herds kept for the purpose of producing calves and raising them to weaning age constitute the foundation of beef production. These calves are raw material from

which the finished steer eventually will be made. The breeding herd needs but little or no grain and other expensive feeds. The margin of profit is quite narrow, consequently the rearing of calves is confined chiefly to those regions where there is an abundance of cheap grazing land. Cows and calves cannot withstand severe winters to the same extent as can the more mature steers; furthermore, regions with a mild climate early in the spring have a decided advantage over regions with late periods of extremely severe weather because the calves are born from four to six weeks earlier and are larger and heavier when marketed in the fall. The Southern and Southwestern States have a decided advantage over those farther north. 2

The climatic conditions favorable to the economical maintenance of beef cow herds are temperatures during the winter that are relatively mild, early springs, and mild summers. Dry beef cows can withstand moderately severe winter weather with very little shelter, but they should have some protection against blizzards, sleet storms, and prolonged spells of extremely cold weather. Quite often/ windbreak is all that is necessary, and in wooded areas and protected valleys no artificial protection may be necessary. Barns or sheds of a relatively cheap nature are necessary in the extreme northern parts of the country. More shelter is necessary in areas with cold wet weather than in those where the cold weather is dry. Although the cows can be exposed to severe conditions, regions where this is not necessary have a distinct advantage in that less feed is required to carry the cow through the winter and the cows

go through the winter in a more vigorous condition. Winter climate, therefore, does not arbitrarily exclude beef cow herds from the areas with severe winters, but it does increase the cost of producing the calf.

A large percentage of the calves are born in the spring months; some breeders prefer to have the calves born in the fall, but this practice is not general especially where the winters are severe and where there is only a meager shelter. Young calves cannot stand low temperatures and cold, damp weather, and if these conditions prevail in early spring it will be necessary either to provide adequate shelter or to delay the calving season; the former adds to the expense of producing calves, and the latter results in the marketing of a light calf or the marketing of a calf after the market has commenced to drop. Naturally either factor means less profit to the calf producer.

Summers with extremely uncomfortable temperatures are not conducive to rapid gains of the calf. In the first place the cow may produce only a small amount of milk when the weather is so hot that she prefers resting in the shade to grazing. If she is to produce a maximum amount of milk for the calf she must do considerable grazing. The calf will consume a large amount of grass as it becomes older, but if it is forced to the shade by uncomfortably hot temperatures it will do less grazing. More of its gain must come from milk. Only meager gains can be expected under such circumstances. Many pastures dry up during hot weather with a further reduction of expected gains.

The wintering of beef cows is an expensive process because of the necessity of feeding large quantities of feed. Pasture does not have to be handled, but a winter feed must be grown, harvested, stored, and fed.
Each step adds to its expense. Regions where the pasture season is exceedingly long have a distinct advantage over those where the cows must be carried through a long winter period. Quite often, however, regions with relatively long winters have other feeds that may greatly offset this disadvantage. Corn Belt farmers have large acreages of corn stalks and large straw stacks. The cows may spend the entire winter in a stalk field and around a stack at a surprisingly small cost.

The beef cow is a consumer of exceedingly cheap feeds. She has more time and energy to expend in the attempt to satisfy her appetite than has the fattening steer or the dairy cow. The steer has to gain weight rapidly, and the dairy cow must produce much greater quantities of milk per cow and per unit of feed. Regions with large quantities of range land and cheap forage may find a very profitable outlet for these products through a beef cow herd. Farms upon which there is a considerable acreage of cheap, nontillable pasture land and upon which there are large quantities of unmarketable roughages, such as corn stalks and straw, may likewise gain much by marketing such feeds in the form of beef calves.

Beef calf production is carried on quite successfully as an extensive enterprise. Very little more labor is required to care for a farm herd of 50 to 80 cows than for one of 10 to 20 cows. Some supervision during the calving season and the necessary labor for feeding the herd during the winter constitute about the only periods where much labor is required. Even this is smaller than that required by other livestock enterprises during similar periods. The farmer with a limited acreage of land, however, will find it unprofitable to engage extensively in beef calf production for the open market so long as there exist in the world extensive areas of free or very cheap grazing lands where large herds are
cared for at the rate of but one man per 500 cows. 3

From the statement made in the above paragraph, one would expect that a beef cow herd has no place on the average sized farm in regions where many other enterprises may be profitable. Such an inference is not true, but under these circumstances the breeding of calves will be of secondary importance to some other enterprise that will utilize more efficiently the available land and labor. The beef cow herd will be a sort of by-product plant through which the unmarketable products of the farm may be successfully utilized. Quite often a farmer finds it profitable to produce his own calves for his feed lots. 4 On such farms the farmer may utilize a patch of non-tillable or rough pasture land to carry his cow herd. His labor may be quite largely devoted to the production of feed crops, cash crops, or other livestock enterprises. The herd causes very little additional expense, other than that for the capital invested, when it is used as a sort of supplementary enterprise on such farms. The returns are small, but at least there are returns from otherwise unmarketable products.

Growing of Stockers. The stocker, an animal being fed and cared for in such a way that growth rather than an improvement in condition may be realized, is the animal in the intermediate cycle of production; the animal is known as a stocker after it is weaned and before it enters its place in the feed lot or the breeding herd. The foremost thing in the mind of the owner of stocker cattle is to feed and manage them in the most economical manner that is consistent with normal growth and development. 5

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5. Ibid, p. 63.
Stocker cattle demand slightly better feed than does a cow herd because they are young and should be growing fairly rapidly, but they are fed economical feeds such as cheap pasture or cheap roughage in the form of hay, straw, fodder, or silage. The stocker can stand a severe winter and heavy storms. Regions where the climate is too severe for a beef cow herd may be able to utilize their rough feeds through stockers. Often a windbreak is all that is necessary in extremely severe weather. The loss with steers under range conditions, unless they actually starve to death, is very small. 6

Stock heifers kept for breeding purposes normally do not move very far from the breeding centers where they have been produced and where they are likely to return as a part of the herd. Ranchmen and farmers normally carry them merely for their own replacements. Stockers intended for the market may be grown out in regions where they were born by permitting them to graze on cheap grass land such as that used by their mothers, or they may be shipped soon after weaning either to other areas where cheap grazing land is available or to the sections where they are to be fattened. 7 Normally when the cattle are shipped to other regions of cheap grazing land the shipment is made in the general direction of their ultimate destination.

Calves born in the Southwest often move to the better grasslands farther north where they are carried until shipped into the Corn Belt for fattening. Those that actually move into the feeder area as stockers are maintained on unmarketable forages such as meadow aftermath, legume

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6. Potter, Ermine L., Western Livestock Management, p. 38
Rotation pastures not fully utilized by the other livestock enterprises, corn stalk fields, and small-grain straw. More costly feeds such as legume hay, corn stover, and silage are added in quantities sufficient to keep the steer thrifty. Stockers often move into the primary feeder areas because many cattle feeders have found that they can afford to buy them as stockers and carry them until they are ready to commence fattening them. Such a practice often results in placing an animal in the feed lot much cheaper than it would have been if purchased when wanted. Seasonal price variations account for this situation.

**Fattening Cattle for Market.** The third and final step in the production of market beef is the fattening of the cattle. This is in reality a finishing process whereby the condition of the animal is increased to meet the demands of the market. It is the most intensive of the three steps. This step may be carried out in either of two ways; cattle may be fattened in the dry lot or on grass. The greatest development of the dry lot fattening has occurred in the Corn Belt where large quantities of fattening feeds are grown. Grass-fat cattle are produced in large numbers on the ranges of the Rocky Mountain, Great Plains, and Appalachian regions. A new practice increasing rapidly in the Middle West and Appalachian regions is that of attempting to put a high finish on grass cattle by feeding a supplement.8

Whenever the grass of an area is sufficiently abundant and nutritious to enable mature cattle to fatten on it without any additional feed, this system of finishing the cattle may be employed quite profitably. Cattle finished in such a manner are often discriminated against by the

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American consumer and tradesman. It happens, however, that most grazing areas are so heavily stocked that they furnish little more than a maintenance ration for the animals they carry. This makes necessary the use of liberal quantities of harvested feed in finishing the cattle for market, consequently the center of the cattle-fattening industry is found where there is the greatest production of such feeds. In regions where considerable pasture is available and where a large supply of concentrates are produced, the cattle may be fattened economically with the concentrates on grass during the summer and fall months.

The necessary feeds for finishing cattle are either a good quality roughage at a reasonably low cost or a cheap concentrate and a moderately good roughage. The combination consists of a legume hay and corn in the Corn Belt, good pasture and corn in the Appalachian region, cottonseed meal and some roughage oftentimes silage in the South, beet pulp in the sugar beet region of Colorado and nearby states, and grass and alfalfa in the range areas. Large quantities of beef are produced on all of these combinations of feeds.

The feeding of cattle requires more labor and supervision than does either of the other two steps. It becomes a competitor for the farmer's time, and as such it may conflict with other livestock enterprises and with crops. Many farmers, however, get around this difficulty by arranging their feeding operations so as to utilize otherwise idle labor. They purchase the cattle in the fall and carry them with the least possible effort without injuring the quality of the cattle until after the crops are harvested. Then the cattle are brought to full feed and are finished before the extremely busy season of the next spring arrives.
Such a scheme provides a means of utilizing the labor available during the winter when otherwise it might be idle. Its interference with other enterprises is reduced to a minimum.

Cattle feeding is not adapted to regions where the farmers are ignorant or where they lack experience with cattle. The cattle must be fed and handled with considerable intelligence or else they may be thrown off feed with a considerable loss of weight. The farmer needs to be a shrewd buyer and seller. His profit from the operations are measured largely by the margin between the purchase and sale price per unit. He must have a knowledge of seasonal price fluctuations, and he must follow closely the market trends. The third limitation of this general nature is the necessity for a ready supply of capital. Furthermore, the feeder must know how to use it intelligently. It may be readily seen that beef cattle feeding has no place in backward communities where the people are shiftless and ignorant.

Snapp states that the cash profits derived from fattening cattle are usually rather low, being seldom more than a few dollars per head. The major returns from such an operation are in the form of the fertility that remains on the farm in manure, the outlet furnished for unmarketable roughages and damaged grains, and the saving of much of the labor necessary to haul the salable grains and hays to a shipping point. Many feeders are satisfied if they can sell the fat cattle for enough to cover the initial cost of the cattle and the market price of the feeds fed. Labor costs and interest on the investment in cattle and

equipment may be sufficiently repaid by the manure left on the farm and
the pork produced by the hogs following the cattle. This narrow margin
limits cattle feeding to those areas with a favorable balance of feed a
large part of which cannot be marketed readily. Regions producing con-
siderable grain and hay which are expensive to market because of the
inaccessibility of the local shipping facilities may find cattle to be
a distinct advantage as a market for these products.

Baby Beef Production. The production of baby beeves is a highly
specialized form of beef production. Strictly fat young cattle are
brought to a weight of from 700 to 900 pounds at an age varying from
ten to fifteen months. Quite palatable and highly nutritious feeds are
absolutely necessary if the young animal is to be brought to a market-
able weight and condition at so early an age. Baby beef production,
therefore, is carried on almost wholly in the Corn Belt where an
adequate supply of grain and other concentrates may be had at a reason-
able cost. 10

The calves are bred, reared, and fattened in a relatively short
time; in fact the stocker stage is omitted and the other two stages are
pretty largely combined. The enterprise becomes, in reality, a combina-
tion of a beef cow herd and a fat cattle enterprise, consequently the
farm upon which such an enterprise is attempted must have a relatively
cheap source of feed upon which to carry the cow herd with very little
labor or other handling expenses. The necessity of a reasonably cheap
supply of highly nutritious feed for the calves has already been mention-
ed. The breeding herd must be of strictly beef type with a pronounced
tendency to fatten at an early age and to put on flesh economically.

10. Ibid, p. 65.
The cows should have a fairly good milking ability because milk is the best growing and fattening feed ever devised either by nature or man. The calves will consume very little roughage; their entire eating capacity is needed for more concentrated feeds. Roughages may be utilized through the cow herd. The combination of the two enterprises in one insures a market for the coarse, cheap feeds as well as the high quality concentrates.

Some attempt has been made to purchase young and light cattle from the range soon after they are weaned. This has afforded the farmer, who wishes to feed out baby beefs but who lacks the facilities or aptitude for maintaining a breeding herd, with a means of securing calves fairly well suited to baby beef production. Inferior calves may be expected because of the hardships of long shipments and the fact that they are unacclimated to grain. In spite of these facts, the farmer who has excellent facilities for a baby beef enterprise but who cannot furnish his own calves may find the use of range calves very profitable. The profitableness of the enterprise is largely dependent upon the margin between the purchasing and sale price.

Dual-purpose Cattle. Cows kept to produce fairly good quality beef calves and a fair quantity of milk are known as dual-purpose cows. They are neither highly specialized beef animals nor dairy cows of the extreme type, consequently they are not likely to be profitable milk or calf producers when an attempt is made to intensify their use for either alone. They do fill a real economic need on the general farm where cows are kept largely to obtain the greatest possible diversification of enterprise and the fullest utilization of all farm products.  

11. Ibid., p. 66.
The farmer may give his enterprises a certain degree of flexibility by including dual-purpose cows in his farm business. If beef calves are of a good price and butterfat is cheap, he may produce calves with no attempt to utilize the milk, but if the opposite condition exists he may find it profitable either to sell the calves as veals or to raise them on skimmilk. Labor costs must be considered; if the farmer has an ample supply of cheap labor he may well afford to milk all or part of the cows, but if labor is scarce or expensive the calves may do more of the milking. Some farmers manipulate the management of the cows and calves so as to have more milking to do during the winter and less to do during the summer. Such a scheme provides for the utilization of the winter surplus of labor; furthermore, dairy products normally sell at a higher price during the winter. If the calf is not sold it may be expected to completely milk the cow, it may have to share a cow with another calf, or it may be fed skimmilk. The dual-purpose cow will be a profitable enterprise on many farms where either milk or beef production alone may be too inflexible to be valuable.

The size of the farms in a region often play an important part in determining whether the cows kept should be of a specialized beef nature or whether they should be dual-purpose cows. The production of dairy products and a calf make the returns per cow much higher from dual-purpose animals. Labor requirements of dual-purpose cattle vary more or less directly with the number kept, but they do not with a beef cow herd. One man could expect a fair wage for nearly full time employment during the fall and winter months from a herd of eight or ten dual-purpose cows, whereas a beef cow herd of considerably greater size would occupy no more of his time and would return no more for his labor.
Farms too small for an exceptionally large herd of cattle may find the more intensive nature of a dual-purpose enterprise to be quite profitable.

Dairy cattle are often too delicate and nervous to be profitably handled under common farm conditions. Dual-purpose cows will make some return even when the feed is poor, the shelter is inadequate, handling methods are irregular, and the labor supply is not ideal; dairy cows would make very disappointing returns under such conditions.

**Purebred Cattle.** A highly specialized form of beef production is the breeding of purebred cattle. A purebred herd may be maintained to furnish cattle for the open market or to supply breeding stock to other beef producers. Comparatively few men are well fitted for the breeding of purebred cattle. The relatively large amount of capital required for animals and equipment, as well as the skill and sound judgment that must be possessed by the manager before success is possible, makes this enterprise one that is better suited to men of considerable experience.

The breeder who plans to sell his calves on the open market depends upon more economical gains and a higher selling price to compensate him for the additional expenses of maintaining a purebred herd. Purebred cattle are normally of a more desired quality than scrubs or crossbred individuals. The dressing percentage is usually higher, and a larger part of the carcass is made up of the desired meat cuts. The butcher can well afford to pay a higher price for such individuals. Considerable controversy exists considering whether purebred individuals make more economical gains than scrubs, cross-bred individuals, or dairy animals. It is reasonable to expect, however, that a purebred selected for his ability to put on large gains quickly will be more satisfactory
than the nondescript individual of which nothing is known concerning his ancestors.

Purebred herds maintained primarily to produce breeding stock must be located in regions easily accessible to a large number of cattle breeders. Feed costs form a much smaller part of the final cost of producing the individual, consequently the abundance of cheap feed is less important. Housing expenses are greatly increased because the prospective buyer will not be favorably impressed by an individual made rough through exposure to the weather.

A factor of great importance to the purebred breeder is the presence of other breeders of the same kind of stock in the same community. An exchange of bulls makes possible the use of higher quality individuals. Local breed associations have considerable value in advertising and in the promotion of general good will for the breed. A community which has earned a prestige for its cattle will be able to draw prospective buyers from long distances. General cooperation and exchange of work and ideas are valuable assets to a breeder whose neighbors have the same kind of stock. It is often an asset to be the only breeder with a given breed of cattle in a community, providing the community is not sold on a competitive breed. If a person is located in a potential beef breeding community in which the local competition is small, he may be able to establish quite an outlet for his stock if he can sell the people on the merits of his breed.

The market for the young stock produced by a purebred herd is not exceedingly limited. Snapp\(^{12}\) states that when it is considered that there

should be a purebred bull at the head of every breeding herd and that
purebred cows should be available in sufficient numbers to supply not
only all necessary breeding stock but a considerable percentage of the
market cattle as well, it appears that an overproduction of purebred
beef cattle is not likely to occur. This, however, does not mean
expensive individuals.

Farmers situated so as to be able to produce purebred cattle for the
open market at a profit will find the business of selling a few individ-
uals for breeding purposes to be an exceedingly profitable outlet when-
ever there is a demand for breeding stock.

Adaptability of the Beef Breeds. Shorthorn cattle are the largest
of the beef breeds. They cross well with scrub or grade cattle produc-
ing calves of a desirable beef type. The Shorthorn is not equalled by
any other breed where grasses are abundant and feed plentiful, but is
is excelled by some of the other breeds in grazing ability where feed
and pasture conditions are not favorable. The Shorthorn excels all
other beef breeds in milk production, consequently it is often used as
a dual-purpose breed. This breed is favored on many small farms because
it will supply milk for the family in addition to raising a calf. 13

Hereford cattle have found favor with the western range men because
of their ability to thrive in regions of scant pastures and on ranges
where waterholes are far apart. Not only do these cattle thrive under
adverse conditions, but they also respond quite well to a favorable
environment. The Hereford cows have been criticized because of their
scanty milk flow, but most if not all of them produce enough to raise a

No. 612, pp. 5 - 6.
good calf if provided with reasonable feed and care. The Hereford breed is well adapted to the very cold climate of the Northwest, and neither the heat of the Corn Belt nor that of the South seems to bother them. They appear to do quite well on the large plantations where good care is not to be expected and where the production of beef alone is desired. Better results may be expected from Herefords than from Shorthorns on unimproved plantations or on farms with only fairly good pastures. 14

Aberdeen-Angus cattle are good rustlers, but they never have been so popular on the ranges of the West as either of the other two major breeds. They rank next to the Hereford and above the Shorthorn as grazers on scanty pastures. The cows give more milk than the Hereford but less than the Shorthorn. Angus cattle will stand either heat or cold well. They are very popular in the Corn Belt because of their reputation for finishing smoothly, fattening readily, maturing early, exceptional vigor, high quality, and general uniformity. They are quite popular with baby beef producers. The breed is becoming more popular in the South and rank next to the Hereford and above the Shorthorn in their general adaptability to average unimproved southern conditions. The Angus has become the favorite breed on the ranges of the extreme South, Florida in particular, because of its ability to withstand the heat of that section and because it does especially well under prevailing range conditions. 15

The Galloway cattle have made their greatest development in the northwest because of their hardy nature and exceptional "rustling"
ability in regions of severe climate and scanty grasses. Because they
do not respond so readily to careful feeding and expert management as the
other breeds, they have not become popular in the Corn Belt States. They
are smaller than any of the other beef breeds. 16

The importance of the Shorthorn as a dual-purpose breed has been
mentioned previously. The only other important dual-purpose breed is the
Red-Polled breed. Red Pollys are strictly of a dual-purpose type. They
are smaller than the major beef breeds and do not have so thick a covering
of flesh. They are more nervous than the Shorthorn but are much
more easily handled than the Aberdeen Angus. They are quite popular in
the Mississippi Valley Region and have given excellent results in the
South, but they have not been used extensively on the western ranges. 17

The Devon cows are good milkers and the steers may be used as work
oxen or for beef. They have never been excelled as work oxen wherever
they were tried because of their endurance, intelligence, and gameness.
The steers do not fatten so rapidly as those of the beef breeds, except
the Galloway, but they do produce meat fine in texture and of good
quality. 18

The Brahman cattle are of minor importance. They are suitable only
for the extremely southern portions of the United States where they have
been used almost exclusively as a beef breed. They were introduced into
the South and Southwest for use on the range where other cattle did not
do well on account of disease and the attack of numerous parasites, such
as the tick, screw worm, fly, and mosquito. Offspring of crosses with

17. Ibid., pp. 24 - 26.
native cattle show resistance to ticks, are good rustlers, make good gains, and have a high dressing percentage.

III. Dairy Cattle.

Economic Position in a Permanent Agriculture. Dairy products are one of the most important classes of human food of all civilized nations. The development of mankind from a state of barbarism to that of a high civilization has been accompanied by an increased per capita consumption of dairy products.

According to Eckles, a large part of the best agricultural lands of the world are utilized for the keeping of dairy cattle. He states that it is a well-known fact that the most prosperous nations, as well as those best developed physically and mentally, are those in which the dairy cow is the foundation of agriculture. Further comments concerning the position of the dairy cow in a permanent system of agriculture are made by Henry and Morrison in the following quotation:

Among all the animals of the farm, the dairy cow stands unequaled as a producer of human food. She converts the products of the fields, much of which are unedible for man, into human food more economically than any other class of animals. Even more important than this economic superiority, however, is the fact that the food she produces is of inestimable value to the human race. In fact, as a human food, milk is in a class by itself, and the dairy cow has well earned the title, "the foster mother of the human race", bestowed upon her by the late W. D. Hoard of Wisconsin.

Two factors immediately arise from the above discussion: (1) as the competition for the best and most ideally located agricultural land becomes more keen, the farmer turns to the dairy cow as the most efficient producer of human food; and (2) as the people become more aware of the basic rules of nutrition and the fundamental need of dairy products in the well balanced and economical diet, their consumption of dairy products increases greatly. The figures presented in Table XII conclusively bear out the folly of attempting to maintain a dense population upon the less efficient products of the steer or the sheep.

The cereals will continue to form the major part of the foods of the world, but large quantities of roughage which are not fit for human consumption are produced along with the cereals. Furthermore, there are large acreages of land not adapted to the production of cultivated crops in most communities; these may be economically utilized in the form of pastures, thus producing more roughage to be converted into human food by means of livestock. Meat producing animals predominate when land is cheap, feed is abundant, and labor is scarce, but when land becomes high priced, feed expensive, and labor more plentiful, the dairy cow gradually replaces the steer in this conversion of rough feeds into highly desirable human foods.

According to Table XII, the hen is the closest competitor of the dairy cow as a producer of protein, and the pig ranks second as a producer of total energy measured in calories. Neither the hen nor the pig consume large quantities of roughages. Instead they compete directly with the human race in that all three use the cereals as a major food, consequently under extremely dense population conditions neither the pig nor the hen will have much of a place except as the consumers of waste
The dairy cow, although she is kept primarily for milk products, furnishes nearly one-half of the beef supply of the United States. A more dense population and higher feed costs will result in the securing of an increasingly greater proportion of the beef supply from the dairy herds. These factors have resulted in a condition whereby beef is a by-product of dairying in Europe, and there is evidence that these same economic conditions are at work in America which will in time cause the beef produced from beef breeds to become too expensive for general use. Dairying has an increasingly important place in a permanent system of agriculture.

Factors Influencing Dairy Production Areas. Successful dairying depends largely upon the proper care and the efficient management of the herd. Whenever there is a good market available for dairy products, the factors controlling the expense of this care and management, combined with transportation costs, largely determine the dairy product production areas.

A fertile farm that is large enough to permit the growing of both feed and cash crops, that has an abundant supply of fresh, pure water, and that is located conveniently to the dairy market is needed for dairy purposes. The dairy cow requires large quantities of feed, consequently a fertile soil that makes it possible to produce these at a low cost is desired. A sufficient acreage of good pasture reduces the quantities of other feeds required and lowers the feed costs by saving the labor.

necessary to harvest, store, and feed harvested crops. A dairy produc-
tion area should be located on a good road close to either a town, a
local shipping point, or a milk or cream collecting route. This makes
possible an easy and economical delivery of the dairy products.

**Feeds Necessary for Dairy Cattle.** The ideal dairy cow ration should
include sufficient pasture, silage, hay, and grains in the combinations
best suited to the immediate region. Good pasture, because of its
succulence, convenience, and cheapness, is an almost indispensible re-
quirement of a good dairy production region. A few dairies are maintained
without pasture, but they must have a specialized market that merits
their location where pasture is not available. Even then, accessible
regions where good pasture is available will offer severe competition.
Dairy cows, because they are generally being handled under very intense
condition and because their nature is less adapted to rough conditions,
demand much better pastures than is necessary for beef cow herds.

The combinations of silage, grain, and hay, although important,
are less exacting than the necessity of good pasture. Various communi-
ties will use different combinations; one of the three may be omitted
under certain circumstances. Hay is perhaps more essential and is more
universally used than either of the other two. Regions well supplied
with a good legume hay have a distinct advantage over those which must
depend upon hay importations. Non-legume hays are less desirable because
of their low protein content.

Bulletin No. 1610, pp. 3 - 4.
An ample supply of fresh, pure water is essential. High producing cows consume large quantities, and if the water supply is limited, their production will be hampered. The purity of the water is necessary not only to insure the good health and vigor of the cows but also to make the milk safe for human consumption. Epidemics of diseases such as typhoid fever often have been traced to dairy cows supplied with a contaminated water supply. Meat producing animals may consume large quantities of contaminated water with little or no danger to the consumer, but this is not true with the dairy cow except when the milk is thoroughly pasteurized before using.

Housing and Temperature Requirements. Dairy cattle require considerably better housing conditions than beef cattle. The dairy barn should keep the cow dry and out of wind and drafts, and it should provide plenty of fresh air and sunlight. Temperature itself apparently is not a vital consideration except in the coldest parts of the United States. There probably is no advantage in keeping the stable temperature much above freezing in winter and there may be a disadvantage if it rises above 60 degrees.

Cool regions have a distinct advantage if not too cold because the difference in the cost of constructing a dairy barn varies very little with moderate climatic changes. Of course a dairy barn in Texas need not be so expensive as one in Wisconsin, but the favorable effects of the cool climate more than offsets the difference in building costs.

In spite of the fact that lower housing costs and lower pasture costs are to be had in the South, dairying has not developed nearly so much as it has in the cooler, shorter season regions of the Northeast. In the first place the northern area is one that has an ample supply of excellent pasture and grass lands. There are fewer competitive crops. The season is too short for the maturity of high yielding varieties of grain corn, consequently the corn grown is used for silage. In the second place cool regions are more favorable than hot ones for the dairy cow as well as for the manufacture of dairy products. Most of the milk supply of large cities, such as New York and Chicago, comes from north of these cities partly because of the presence of pastures and partly because of the cooler climate.

Social Factors Influencing Dairying. One of the greatest difficulties encountered in conducting a dairy farm is generally considered to be the problem of securing sufficient and satisfactory labor. If the operations are not so large but that the farmer and his family may care for the dairy enterprise these troubles may be largely removed. The necessity of treating the cow carefully at all times and the fact that the work becomes somewhat monotonous because it must be done regularly every day tend to make dairy work exacting and irksome. It is hard to get hired help that will always give the cow the treatment necessary and that is willing to work as steadily as is required. The hired man who has worked hard all day in the field can hardly be expected to have utmost patience with a

cow made restless by hot weather and flies. Rough treatment invariably results in reduced milk production. Furthermore, cows should be milked and cared for regularly by the same person, consequently if the hired labor is more or less intermittent and transitory, the owner cannot expect the best results.

Dairying, on the other hand, is favorably adapted to conditions where the labor supply is large and of good quality. Normally a higher type of farm labor may be secured if year around employment is furnished. A grain farmer usually needs additional help only during the seeding and harvesting season. He may have difficulty in finding a competent man who is willing to work only a few months of the year. Furthermore, the dairyman can quite easily utilize family labor. Children may be too small to work in the hay field, but they can tend to cows very well. The milking of the cows furnishes a good method of utilizing the children's time before and after school. Such work does not have the faults often attached to child labor as known in cities.

The nationality of the people in a given community may have considerable influence upon whether they will be dairymen. The dairy region of Minnesota, for instance, is largely made up of Scandinavian farmers.

Other Economic Factors. Dairying is a complementary enterprise on the one hand and a competitive one on the other. It materially aids the production of crops in that it boosts the fertility of the soil. Not only is a large part of the crop marketed through the dairy herd returned to the farm in the form of manure, but additional fertility from purchased protein supplements is added. Furthermore, the dairyman is more likely to include legume crops in his rotation.
Another factor that is partially complementary and partially competitive is the labor required by the dairy herd. The cows furnish employment on rainy days and during the winter as well as during the crop production season. The herd interferes with field operations when the farmer can work in the field, and it furnishes him something to do when he cannot otherwise use his labor.

Regions which depend upon extremely seasonal enterprises that make only one set of returns per year may well afford to include a minor dairy enterprise in their farm operations. A small income at short intervals, that will supply the family with much of its immediate cash necessary for living expenses, may tend to raise the standard of living much above the level that would be had otherwise. A small dairy herd, therefore, would serve as a sort of subsistence enterprise.

Eckles and Warren state that in dairy regions the kind of product that is to be produced is controlled by the distance that the products must be shipped. Milk, the most bulky and the most perishable of the dairy products, is produced nearest to the places where it is to be consumed. Butter, cheese, and other manufactured dairy products are concentrated enough to permit their shipment long distances. Cream is more concentrated than whole milk.

Milk Produced for Fluid Consumption. Production areas of milk to be immediately consumed in the liquid form tend to concentrate about the large population centers. Transportation costs are made quite high by the perishability and the bulkiness of the product. The producer nearest the

market has a distinct advantage because of the costs of delivering his product to the market centers.

Small cities ordinarily are supplied with milk produced on specialized dairy farms within a few miles of the city and delivered by the dairyman directly to the consumer. As the size of the cities increase such a supply of milk becomes inadequate, and the dairymen find that it is no longer profitable to operate dairies on the outskirts of the city. The farmer at some distance from the city, where the land is relatively cheap with a resultant cheaper feed cost, will produce milk to be delivered to the city by truck or train. An intermediary organization, the retail milk distributor, buys the milk from the dairymen, processes it, and delivers it to the consumer. This division of functions is made necessary by the more complex situations of large cities.

The dairymen who makes his own city deliveries must be located very much closer to the city than the dairymen who sells to the distributor. Furthermore, the first dairymen must have a larger herd to make his delivery unit of an efficient size. The other dairymen may make the dairy enterprise either a major or minor part of his farm business. He does not necessarily need to be specializing in dairying. Those farms nearer the city will provide the milk supply because the transportation costs are more favorable to them.

Milk produced for immediate consumption in the liquid form commands a higher price and takes precedence over all other dairy products. Dairymen who have access to a whole milk market will normally sell their

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product on that market rather than market it for manufacturing purposes. Quite often, however, there are large quantities of manufactured dairy products made within the whole milk zone as a means of utilizing surplus milk or of expanding the business organization for more efficient operation.

An item of expense important on farms producing market milk is that of cooling the milk. Milk must be cooled immediately after the cows are milked. Those farms which have a natural supply of cold water, at least during the warmer months, have a distinct advantage over the farms which must use artificial cooling processes. Milk produced for other purposes need not be cooled so quickly nor so thoroughly.

Market milk producers must be better trained dairymen than the producers of manufactured dairy products. The extreme sanitation and care necessary in handling the cows, the milk, and the milk utensils is much greater on market milk farms. Butter producers normally have to pass no sanitary inspections. This added care necessary on the market milk farm requires more capital invested in equipment and probably in cows and land as well as more labor, consequently such a dairymen must be a better business man than would a dairymen who must manage less invested capital or less labor per unit of production.

Butter Production. Butter production thrives in regions where the population is thin, where natural grazing conditions are good, and where grain can be easily grown. The Central Western States possess these necessary prerequisites. In spite of the fact that good dairy cows are essential for maximum returns in any branch of the dairy industry, much of the butter made in the great butter producing area of the Middle West is really a by-product of the beef industry. Skim milk and buttermilk may be advantage-
Butter is much less perishable and is considerably more valuable per pound than is whole milk. It can be shipped long distances, consequently it will be produced beyond the areas influenced by whole milk markets. It is a commodity that will be produced where the production costs are most favorable in spite of a relatively great distance to the consumption center. Areas with cheap pastures and winter feeds have a distinct advantage.

The location of the creamery is of fairly great importance because cream is bulky and perishable, but ordinarily any area well adapted to butter making will be within reach of at least one creamery. The quality of the butter, however, is influenced greatly by the distance from the farm to the creamery and by the method of concentration.

Good butter cannot be expected from creameries which depend upon distant cream stations. The farmer may deliver his cream at long intervals, consequently it is sour before ever starting to the creamery. The station operator probably has too small a volume to grade the cream according to its quality, and if he did he probably would not know how to do so. As a result the good and bad cream is all dumped together and sent to the creamery.

Some communities have a distinct advantage in that they are on truck routes which pick up the cream at short intervals of time. Properly operated truck routes not only result in higher returns for the cream because of a better quality, but such routes are proving to be both more serviceable and more efficient than the cream station. Communities where a good cream

truck route exists have a distinct advantage over those which must depend upon cream stations.

Butter manufacturing on the farm for other than local consumption is not of extremely great importance. Formerly butter manufacturing was a household task, but now this practice is largely disappearing as a commercial enterprise. Butter making is well adapted to large scale operations, consequently a creamery manufacturing several hundred thousand or a few million pounds of butter may do so at a much lower per unit cost than the farmer. Farm butter is usually of an irregular and generally inferior quality. Creamery butter is much better adapted to large scale methods of distribution and sale because it is already assembled and may be readily put up in packages of uniform size and quality.

Butter dairymen need not be large dairymen. Normally the farm will have other important enterprises as well as dairying. Beef cow herds may provide large quantities of cream when labor is cheap enough in relation to butter to merit its use for milking the cows. The skim milk may be used to raise calves and to feed pigs or chickens. Although more efficient operations and better care of the cream may be possible with fairly large herds, the farmer with only one or two cows may have some income from cream sales. Such a tiny dairy enterprise might be too small to be efficient when considered as a separate enterprise, but many farmers find it profitable to keep a few cows to utilize available rough feeds, pasture, and family or hired labor which might be a complete loss otherwise. The sale of whole milk either as market milk or for cheese and other manufactured products is not nearly so well adapted as a minor enterprise on a general livestock or grain farm. Butter production is a very flexible enterprise that may be combined under quite varying conditions with a
Large number of other farm enterprises.

Large quantities of butter are manufactured in the market milk areas. Fluid milk consumption is not exceedingly seasonal, but milk production fluctuates considerably. Much of this surplus is manufactured into butter. The skim milk and butter milk are also utilized either for fluid sales, manufacturing purposes, or livestock feeding.

Cheese Production. Cheese production thrives under practically the same conditions as butter production, except that cheese dairymen are necessarily more specialized. The milk used for cheese manufacturing on a commercial scale must be of good quality. It should be fresh, clean, of low bacterial count, and possess a clean, desirable flavor. Milk which has any abnormalities in flavor or in odor must be avoided. A high-quality cheese cannot be manufactured from a dirty milk or a milk containing large numbers of bacteria which are found associated with unsanitary methods in the dairy. If extensive fermentation has taken place the milk is practically useless. There is no treatment that can be depended upon to improve a low-quality milk for the manufacture of cheese.

It may be deducted from the above paragraph that a producer of milk for cheese should use considerable care with the milk. He must understand dairying and must be equipped to handle the milk as it should be, consequently his operations must be large enough to permit the use of efficient methods of production, cooling, and delivery. The dairy enterprise on such a farm must be the major or one of the major enterprises on the farm if it is to be large enough for efficient operating practices.

A producer of milk for cheese must be a bona fide dairyman. He cannot be a beef cattle man or a grain farmer who wishes to supplement his earnings with a small income from milk for cheese. Such a farmer will find the production of cream for butter much more suitable to his conditions.

Cheese is easily transported, keeps well at ordinary temperatures, and can be made economically in small factories.\(^{33}\) The matter of location near consumption centers is not important, consequently cheese production areas will be located where good quality milk can be produced the cheapest. Since farms that are specifically dairy farms are necessary, cheese production will be limited to regions generally well adapted to dairying. The production area is further limited in that milk sold for cheese usually brings in much smaller gross returns per unit than that sold as market milk. Regions well adapted to dairying that are not near enough to cities for a market milk outlet are suitable for the production of cheese. In general the cheese factories are located in the northern part of the country where there are cool nights and an abundance of cold water. Cheese making has been carried on in the high altitudes of the Western States and in the mountains of North Carolina, Virginia, and Tennessee.\(^{34}\)

Other Dairy Products. Ice cream manufacturing usually takes place in or near cities of considerable size. It is a rather bulky product and it must be kept at a low temperature, consequently farms producing milk for ice cream purposes are located near the cities. Market milk and ice cream milk are often produced within the same areas and are generally delivered to the city plant in much the same manner. Quite often the milk dealers

use the surplus milk purchased as a margin of safety in their operations for ice cream purposes.

The various powdered and condensed milk products come from areas very similar to cheese production areas. Large quantities of milk are required. The processing plant must be within trucking distance of sufficient available milk to insure its operation. Some classes of condensed and powdered milk need not be of a very high quality; others must be of an exceedingly high quality.

**Purebred Breeding Herds.** A large number of dairy cattle breeders have purebred herds from which a considerable part of the income is derived through the sale of breeding stock. These breeders are generally located comparatively close to the market milk sheds because they wish to have a good outlet for the milk produced and because of the nearness to a large number of potential customers. Many dairymen do not raise their own heifers to keep the herd built up but buy cows when they need to add to their herds. Heifers can be raised at some distance from the market-milk centers much more cheaply than they can near such centers. Expensive milk and feeds make the cost of young animals very high on the farms near the cities.

**Factors Influencing Breeds.** Holstein-Friesian cattle are the largest of the dairy breeds. They have, as a breed, the best disposition or temperament of any dairy breed. Holstein cattle are better adapted to large herds where they probably will be handled by hired labor that is more or less careless and inefficient. Holsteins do best on rather level, rich pastures in regions where liberal feeding is practicable. The breed is easily surpassed by the Jersey and Ayrshire, especially the latter, as grazers on hilly or scanty pastures.
Holsteins will not withstand hot weather so well as some of the other breeds. The ability of the Jersey to endure heat better than the Holstein undoubtedly has some relation to the fact that the Jersey is the leading breed in the southern part of the United States and the Holstein in the northern part. Holstein cows give larger quantities of milk than the other breeds, but it tests lower. The average breed test is about 3.45%. Markets demanding large quantities of low testing milk are especially suited to the Holstein breed.

The Jersey is the smallest of the major dairy breeds. Jerseys are quite sensitive. They respond quite effectively to whatever treatment they receive; that is when they are carefully handled they become very gentle, but when carelessly handled or abused they respond very much the reverse. They are easy keepers, but do better when well cared for and fed. They do better than the Holstein but not so well as the Ayrshire on rough scanty pastures. The breed thrives well in warm southern climates. Jersey milk has a higher fat content than any other dairy breed common in this country; this breed has always led in economy of production of butter fat. Large numbers of Jerseys will be found in the butter production areas.

Many market milk producers keep a few Jerseys along with their Holsteins to raise the test of their milk to the level demanded by the market. Markets which make a butter fat differential on the market milk price are favorable to the Jersey, especially when transportation costs are relatively high. Jerseys, therefore, will have a greater advantage in that part of the milk sheds farthest from the market center.

36. Ibid., pp. 67 - 73.
The Guernsey cow is slightly larger than the Jersey. She has a good temperament and is much better adapted to careless or rough handling than is the Jersey. The Guernsey yield of milk and fat test is similar to that of the Jersey; the Jersey leads slightly in the richness of milk and the Guernsey in total milk production. Guernsey milk ranks highest of all the breeds in color, consequently it is in demand to mix with that of other breeds for the sake of the high color it imparts. This high color often commands a premium on the market. The breed has a place in the market milk area largely because of this milk color and because of the relatively high fat test. The economy of production of butter fat gives it a more stable place in the butter producing regions.

The Ayrshire ranks between the Holstein and the Jersey in size and in disposition. This breed has excellent grazing qualities; they will thrive and keep in excellent condition where the larger breeds, especially the Holstein, find it difficult to support themselves. The milk tests higher than the Holstein and is produced in larger quantities per cow than that of the Jersey or Guernsey breeds. This large yield of average composition milk makes the breed well adapted for the production of market milk. It lacks color, but the small fat globules result in less trouble from churning in transit. It can be hauled long distances without churning. The milk is well adapted for cheese making because of the small fat globules and the relatively high per cent of casein.

The Brown Swiss, a breed of plain, substantial, and well proportioned animals, are about the same size as the Holsteins. They have an especially good disposition being quiet and docile and easily handled, consequently

37. Ibid, pp. 81 - 94.
38. Ibid, pp. 91 - 94.
they are well adapted to poor labor. No other dairy breed does so well under generally adverse conditions and rough treatment. The calves are exceptionally large at birth. Very little milk is required to make a good veal calf. In composition the milk of this breed is very satisfactory for market milk purposes, containing about the proper amount of fat and solids.

IV. Hogs.

Place of the Hog in a Permanent Agriculture. The hog is one of the most important sources of meat for human consumption. Marketable hogs may be produced by a large number of farmers under quite varying conditions. A study of Table XII. shows that the hog is one of the most efficient animal producers of energy that is known to mankind. The hog, like man, is primarily a consumer of concentrates, consequently it could be expected that the species of animals which efficiently consume roughages in large quantities will have a more permanent position in a world agriculture when the world population increases sufficiently to make acute the competition for food.

Although the hog consumes large quantities of concentrates that might be more efficiently consumed directly by man, there is a place for it as a producer of human food. Large quantities of waste products, garbage, and by-products of the grain mills, packing houses, and industrial plants may be converted into palatable human food by the hog.

A unit of grain suitable for human use may be fed to hogs with no loss of efficiency provided it is accompanied by a quantity of feeds not fit for man in their existing form. The chicken is the only other animal of economic importance capable of doing this.

The present day consumer would rather eat a pound of pork than he would five or more pounds of corn required to produce the pork. Man is not an entire vegetarian by choice, consequently he will consume large quantities of meat as long as he is able to purchase meat. Pork makes up a large part of this meat because it can be produced more cheaply than the other major meats. It takes approximately six pounds of grain and six pounds of hay to produce one pound of lamb (live weight), ten pounds each of hay and corn to produce a pound of beef, and about five and one-half pounds of corn to produce a pound of pork. Furthermore, the hog dresses off about 25% as compared to 35 to 50% off from the sheep or steer. Another factor of great advantage to pork is that most of the hog carcass may be readily prepared as cured meat in which form it will keep in any climate.

Many farmers raise hogs as a sort of minor enterprise to utilize waste products and garbage from the house, unsound and unmarketable grains, refuse from truck crops, or by-products of the dairy industry. Beef cattle feeders often secure their profit from the pork produced from the undigested corn excreted by the steers. Hog production is not a highly specialized enterprise that is beyond the reach of the average farmer.

The prolificacy and early maturity of the hog, the inexpensive equipment, and the small capital investment place hog production within reach of almost every farmer. 41

Localisation of Hog Production. It may be readily reasoned from the factors presented above that hog production is quite general. No other kind of livestock except poultry is produced for home consumption in such wide areas; hogs are raised and slaughtered for food in every county of the United States. Commercial production of hogs, however, is more concentrated than any other kind of livestock. Nearly half of the hogs of the country are found in the Corn Belt where they have attained a dominating position in the farm business. 42 The production of pork falls into two general classes either of which is large enough to merit further consideration. Hogs are produced for farm use and for the market.

Pork Production for Farm Use. The chief requirement necessary for use is that of feed for the hog. A hog requires very little room and the shelter need not be elaborate. His care is not complicated. He does need something to eat, but nearly every farm can find sufficient feed for a pig or two thus providing the family with a cheap supply of meat. Hogs kept for family use neither represent any great money outlay nor receive very little feed that could be converted into cash. 43

Market Hog Production. The production of market hogs makes up approximately three-fourths of the total hog production in the United States. Over 95 per cent of the commercial hogs grown in the United States

41. Ibid. p. 182.
42. Ibid. p. 189.
43. Ibid. p. 201.
are produced in the humid eastern half of the country. Approximately
60 per cent are in the Corn Belt, 15 per cent are in the Cotton Belt
and other regions south and southeast of the Corn Belt, and 15 per cent
are in the Dairy Belt of the North. The variation of farming systems
into which the production of market hogs fits are many, but they fall
into the three general types found in the Corn Belt, the Cotton Belt,
and the Dairy Belt respectively. 44

Hogs in the Corn Belt. The growing of corn and the raising of hogs
are more interdependent than the production of any other two farm
enterprises in the United States. Most other forms of livestock may
consume varying proportions and kinds of grain and roughage either on
farms or the open range, but hogs are generally confined within comparati-
vely narrow limits and are almost always fattened on corn where that
crop is available. 45 An examination of Table XIII and Figure 39 shows
that the production of corn and hogs are very closely related.

The leading corn states are also the leading hog states, and those
states producing an exceptionally small amount of corn per 100 acres of
farm land also have a limited number of hogs. The few exceptions to this
general relationship are caused by the production of hogs on other feeds.
There is a very small acreage of farm land in the District of Columbia,
but large numbers of hogs are produced on garbage. The competition of
dairying and human food manufacturing plants lowers the relationship
between corn and hogs in Illinois and a few of the Eastern States. A

Table XIII.

RELATION OF CORN TO HOG PRODUCTION, 1929.

<table>
<thead>
<tr>
<th>Rank</th>
<th>State</th>
<th>Bushels of corn per 100 acres Farm</th>
<th>No. of Hogs per 100 acres Farm</th>
<th>Rank</th>
<th>State</th>
<th>Bushels of corn per 100 acres Farm</th>
<th>No. of Hogs per 100 acres Farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Iowa</td>
<td>1143.6</td>
<td>29.6</td>
<td>25.</td>
<td>West Virginia</td>
<td>132.4</td>
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<td>2.</td>
<td>Illinois</td>
<td>898.7</td>
<td>15.2</td>
<td>26.</td>
<td>Florida</td>
<td>131.7</td>
<td>11.3</td>
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<td>3.</td>
<td>Indiana</td>
<td>883.4</td>
<td>17.0</td>
<td>27.</td>
<td>Wisconsin</td>
<td>118.9</td>
<td>7.4</td>
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<td>4.</td>
<td>Nebraska</td>
<td>483.2</td>
<td>10.5</td>
<td>28.</td>
<td>Michigan</td>
<td>91.5</td>
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<td>5.</td>
<td>Ohio</td>
<td>474.9</td>
<td>12.9</td>
<td>29.</td>
<td>District of C.</td>
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<td>6.</td>
<td>Delaware</td>
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<td>Colorado</td>
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<td>1.6</td>
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<td>5.6</td>
<td>31.</td>
<td>Texas</td>
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<td>Rhode Island</td>
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<td>4.7</td>
<td>34.</td>
<td>New York</td>
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<td>1.2</td>
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<td>36.</td>
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<td>Vermont</td>
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<td>0.2</td>
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<td>New Hampshire</td>
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<td>Oregon</td>
<td>4.3</td>
<td>1.4</td>
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<td>42.</td>
<td>Wyoming</td>
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<td>0.4</td>
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<td>43.</td>
<td>California</td>
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<td>2.1</td>
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<td>20.</td>
<td>Louisiana</td>
<td>195.4</td>
<td>8.1</td>
<td>44.</td>
<td>Utah</td>
<td>4.1</td>
<td>1.4</td>
</tr>
<tr>
<td>21.</td>
<td>South Carolina</td>
<td>185.5</td>
<td>4.5</td>
<td>45.</td>
<td>Washington</td>
<td>2.5</td>
<td>1.4</td>
</tr>
<tr>
<td>22.</td>
<td>Georgia</td>
<td>178.9</td>
<td>6.1</td>
<td>46.</td>
<td>Arizona</td>
<td>2.3</td>
<td>0.2</td>
</tr>
<tr>
<td>23.</td>
<td>Arkansas</td>
<td>170.6</td>
<td>4.8</td>
<td>47.</td>
<td>Maine</td>
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Bushels of Corn to 100 Acres Farm Land

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Figure 39. Relation of corn to Hog Production 1929.

Source: Table XIII.
large part of the corn produced within a comparatively short distance of Chicago is sold as cash grain. It moves either into the dairy regions within reasonable shipping distances of the Great Lakes or into the nearby food plants. Dairying and poultry are too strong as competitors in the Eastern States.

Hogs fit into many different variations of the farming system found in the Corn Belt. Cattle kept for either beef or dairy purposes will not normally consume all the grain produced on the farm. A few sows will quickly and profitably balance this grain-roughage relationship with the necessity of very little added capital or labor. Furthermore, they will provide a means of utilizing by-products of these enterprises and of marketing the undigested excretions of the cattle. The grain farmer who plows under his surplus roughage for fertilizer purposes will find it profitable to keep a few hogs to utilize waste feeds and to provide his own meat. While so doing he will usually produce a surplus of hogs which may be sold.

Tenant farmers, who do not know what their next year’s plans may be and who have a limited amount of capital, find that the hog furnishes a good means of expanding and diversifying their operations. The rapidity with which a herd may be built up to a productive stage and the ease with which it may be sold with little or no financial loss remove the probability of difficulties which may develop when tenants attempt to include other livestock enterprises in their farm plans. Tenant farms are often poorly equipped with buildings, but there are generally facilities that may be converted into fair hog quarters with little trouble. One difficulty often encountered on Corn Belt tenant farms, as well as elsewhere, is the lack of hog-tight fences. Land used for hog production must be well fenced.
Hog production is generally much less risky than the other livestock enterprises. The purchase of feeder cattle is very speculative. A dairy herd is quite susceptible to such diseases as contagious abortion, tuberculosis, and garget, any one of which may completely ruin the herd in spite of fair care and management. In case of a hog loss there is very little invested, and a new start may be secured with little trouble. The farmer with a limited amount of capital will find hogs much better suited to his needs than most other productive livestock enterprises.

A good hog farm in the Corn Belt and elsewhere should be well located with respect to roads and accessibility to market. Beef cattle may be driven fairly long distances to a shipping point or market, but fat hogs are much more difficult to handle in such a manner. They should be hauled all the way from the farm to the stockyards. Sanitary conditions are more favorable in regions where the land is rolling. There should be adequate facilities for rotating the hog pasture whenever there are very many kept in proportion to the amount of land. Internal parasites, such as round worms, are best controlled by providing the growing pigs with clean, uncontaminated pastures. Old hog lots should be avoided. This problem is not great on farms employing temporary pastures because the pigs are on new land each year. Some system of rotating the pasture available to the hogs should be provided if permanent pastures are used. Rapidly fattening hogs heat easily, consequently they need ample shade. This should not be a limiting factor because of the ease with which artificial shade may be provided. Natural shade, however, is a distinct advantage. Hogs demand a good supply of clean, fresh water.

Hog Production in the South. The lack of corn in the South has been one of the major factors limiting hog production in that area. Along with this lack of corn is the fact that the major crops of the South are not feed crops. Commercial hog raising and a large acreage of cotton do not go together. Cotton and tobacco occupy much the same position in the farm rotation systems as does corn, therefore, a high acreage of either of the two means a low acreage of corn. The other crops of the rotation are grown largely for work stock feed and for fertilizer. There may be available large quantities of roughage, but it cannot be fed to hogs very satisfactorily. Other livestock enterprises which will utilize the roughage and which need relatively little grain are more satisfactory on such farms. A large part of the grain produced is used for work stock.

Upon examining Figure 89 it may be noticed that the South produces hogs in greater quantities than might be expected after considering the small amount of corn produced and the use of a large part of the corn by work stock. There are no exceedingly large cities to produce large quantities of garbage, and dairying does not furnish large quantities of milk by-products as it does in Minnesota and Wisconsin. This proportionately large number of hogs is largely the result of two factors; namely, (1) the diversification of agriculture forced upon many sections of the South by the necessity of soil maintenance and the ravages of the cotton boll weevil, and (2) the production of large numbers of hogs in woodlands and swampy areas not included in the census as farm land.

Huge quantities of peanuts and velvet beans are used by the farmers to improve their land. Considerable hog pasture may be secured with very little loss of the potential fertility value of the crops. Peanuts may be grown for market purposes and the fields may be cleaned up by hogs after
the bulk of the crop has been harvested, or the peanuts may be grown chiefly for hog pasture. The kind of crops grown on southern farms makes it possible to pasture the hogs almost the entire year keeping them in good growing condition and requiring only a minimum of concentrates to finish them. It is along these lines that the hog producers of the South can and do compete with those in the Corn Belt. 47

Large acreages of woodland common in the mountainous and hilly regions of the South provide considerable though irregular quantities of mast suitable for hog production. Many hogs are raised in the swampy regions where they rustle for themselves. It is true that these hogs are of a nondescript type, but their production generally costs very little other than the trouble of rounding them up. Pork production under such circumstances is small as compared with that of other more scientific means, but it does provide an income from such areas.

The South has a distinct advantage in hog production because of the long season of favorable pasture conditions and the variety of good pasture crops that may be used for both summer and winter pasture. The long seasons of rather mild weather may cause more trouble from parasites, but this difficulty may be offset by rotating the pastures and by employing good sanitation practices. Fat hogs may not be produced on good pasture, but good thrifty pigs will grow well. When they reach a size near that of the wished market weight they may be finished off on whatever concentrate is available. Such a system may be employed quite profitably in regions with huge quantities of good pasture and a limited amount of grain. The

poor quality of the labor common in the South can be better utilized for hog production than for almost any other type of livestock.

**Hog Production in Dairy Regions.** Dairy cows are the dominating factor in the farm operations of the dairy regions of the Lake States. The farmer plans his cropping system to meet the demands of the cows. In regions where the rotation may contain one or more grain producing crops, the farms normally produce more grain than can be effectively utilized by the dairy cow. A few hogs work into such farming systems admirably. This grain may be corn in the Corn Belt, but in the states immediately north of the Corn Belt considerable barley is grown. It makes nearly as good a hog feed as does corn. 48

The hog has an even greater place in those dairy regions where a large part of the milk is used for butter or cheese. The skimmilk, buttermilk, and whey, by-products of the butter and cheese enterprises, are unexcelled as a feed for growing pigs. Even small quantities added to the concentrate and forage ration give highly satisfactory results. Few hogs are kept on dairy farms in the city-milk or condensery areas. 49 When hogs are kept on such farms it is primarily for the purpose of more fully utilizing the grains grown on the farm.

Few hogs are found on the dairy farms of the New England and other Eastern States because of the scarcity of corn and other grains suitable to hog production. The quantity of skim milk and other by-products available for hog feeding is also limited. The production of hogs in these states is largely a matter of raising the farm meat supply and of utilizing

the garbage made available by the large cities.

Hog Production in the West. A considerable number of the hogs slaughtered in the Mountain and Pacific Coast States come from the western part of the Corn Belt. Many western farmers are taking advantage of the nearness of the market by producing hogs. Barley and wheat, both of which may be used to fatten hogs, grow in abundance in many of the great valleys of the Western States. These lands also produce good alfalfa which makes hog growing a possible and profitable business. The shortage of water probably limits hog production in many places of the West where barley or wheat and alfalfa are grown.

A factor which might tend to cause an increase of hog production in these western valleys is that of transportation costs. The grain must be shipped long distances, consequently it might be profitable to feed it to hogs purely as a means of reducing the transportation costs on the grain. This factor of transportation is largely the reason why hogs are raised in Nebraska and Iowa and corn is sold as a cash crop in regions near Chicago. The Western States which are long distances from large population centers will tend to market their crops as cheaply as possible. The grain may find an efficient method of getting to market in the form of pork.

General Factors Influencing Hog Production Areas. From the foregoing discussion it is apparent that the question of feed is largely responsible for the determination of areas adapted to hog raising. A major part of the cost of producing pork is the feed cost, consequently the availability of cheap feeds largely determines the economy of pork production. It has been noted that areas with an abundance of corn, milk by-products, or garbage

are important hog regions. A few other crop areas, such as those of peanuts and barley, also produce many hogs.

Climatic factors have very little direct affect upon hog production areas. Warmer farrowing houses and delayed spring farrowing are necessary in the colder parts of the country. In regions of extremely cold winters and short warm seasons, one litter per sow per year may be all that can be expected. Fat hogs tend to languish during the hottest weather of the summer. Areas with long seasons of extremely hot weather will be handicapped considerably if they attempt to have the hogs fattening rapidly during such weather. Arid regions will not have ample water for large herds of hogs. The chief influence of climatic and soil factors is that of their control of crops.

Factors Influencing the Breeds of Hogs. The breeds of the lard type and the breeds of the bacon type make up the two distinct classes of hogs produced in the United States. The lard type hogs are bred more extensively than those of the bacon type throughout all parts of the country. The Duroc-Jersey, Poland China, Chester White, Berkshire, Hampshire, and Spotted Poland China are the leading breeds of the lard type. The Tamworth and the Yorkshire are the only breeds of the bacon type bred extensively in this Country.

The lard type hog predominates in regions where corn or other excellent fattening feeds are available. Bacon hogs, on the other hand, are produced in regions which depend primarily upon small grains and other feeds of a less fattening nature for hog feed. The lighter bacon hogs will usually do better in woodlands and swampy regions where they must rustle for themselves and where feeds are scanty.

Two distinct commodities, wool and mutton, result from sheep production. Formerly the sheep was raised primarily for wool, but the industry in the United States has been passing through a transition stage. Some sheep raisers are specializing primarily in mutton production while others are combining mutton and wool production quite profitably. The number and size of flocks in most of the western range states have been declining. There has been a distinct trend toward the more general production of wool and mutton in the farm states. 52

Soil and Climatic Factors. The natural home of sheep is in areas that are high and dry. They will thrive on any land except that which is wet and swampy. The sheep raising industry has been carried on with success in tropical regions with low rainfall, but the rearing of sheep in regions of high temperatures and high rainfall has not been generally successful. 53

Sheep production in the United States is of particular importance in the rolling and hilly grass producing regions of the Eastern and Central States, in the more arid portions of the West, in the rugged range territory adjacent to and including the national forests, and in the fenced range area of southwestern Texas. The adaptability of sheep to a wide range of climatic conditions, their ability to go several days and weeks without water when on succulent feed, and their fondness for shrubby and weedy types of forage not consumed by other types of livestock make it possible to keep sheep in regions that would otherwise be unutilized.

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This is especially true in the arid parts of the country. Sheep prefer and do well on pastures that are too short for cattle.

**Types of Sheep Production.** There are three distinct phases of sheep production in the United States. Each one has a definite place in the agriculture of the country. These systems are (1) the keeping of small flocks on farms, (2) the running of sheep in large bands to utilize extensive range areas, and (3) the fattening of range sheep on irrigated and Corn-Belt Farms.

**Farm Flocks.** Farm flocks in the eastern part of the country are most frequently found in the hilly and mountainous regions where much of the land is too rough to farm and where it must be kept in pasture. Sheep frequently form one of the major enterprises of the farm in such districts. Dairy regions contain very few sheep unless there is an excess of pasture or unless part of the pasture is too rough and steep for dairy cattle. Farm flocks are very infrequent in level areas where most of the land is tilled. It is seldom that any special crops are grown for sheep except on a few highly specialized purebred farms. The sheep are generally turned onto pasture as early as possible in the spring. They remain there until the crops have been harvested, at which time they are allowed the run of the fields to graze on the crop residues and weeds. They are carried through the winter on hay and other sheep or unsalable roughages. Very little or no grain is fed.

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55. Ibid, p. 246.
A small flock requires very little attention, and farmers who have a quantity of unmarketable roughages in the form of hilly pastures, crop residues, or weeds may find that they can get a good profit from an investment in a few sheep. Some income is assured from the fact that both lambs and wool are being produced. The exact size of the flock will depend upon the availability of cheap roughages that cannot be more profitably marketed through cattle. More profitable crop and livestock enterprises normally demand first consideration as a major enterprise on those farms where such enterprises can be produced. The sheep flock assumes the role of a minor enterprise used to profitably market feeds otherwise unmarketable.

Spring Lamb Production. A system that provides for a sheep flock of major importance has been developed in regions where there is an abundance of winter pastures and where land is not exceedingly high priced. Much of the mountainous region of the entire Appalachian Mountain Region, together with the adjacent sections in Tennessee and Kentucky, is devoted to the production of high-quality early lambs destined to be sold on the eastern markets.

The type of lamb most in demand on the market is the lamb that reaches a desirable weight and finish while it is still a suckling. A region which has an exceedingly early spring and a mild winter is quite favorable to spring lamb production. Such an area permits the lambing season to be very early without the necessity of expensive lambing barns. Since the lamb is largely a milk product, it is advantageous to provide the ewe with liberal quantities of good feed that will induce heavy milk production. A succession and a variety of fresh forage crops produce the maximum milk flow of

The southern part of the above region, including Kentucky and Tennessee in particular, is admirably situated for spring lamb production because of the earliness of the spring and because of the use of winter cover crops for early spring pasture. The flock may be left on fields of fall sown small grain or on fields of winter cover crops such as rye, vetch, or crimson clover from the beginning of the lambing season until the regular summer pasture crop is ready to be pastured. Permanent grass pastures may be well suited for ewes and early lambs, but as the lambs grow and need more milk the feed is likely to be cut short by dry weather. Usually, however, the lambs can be marketed best before the usual date when the pastures begin to languish.

Another factor encouraging sheep production in regions with large quantities of pastures of a temporary nature is the necessity of avoiding stomach worm infestations. Lamb losses by death or by lack of thrift are most serious among flocks that are kept season after season on old grasslands. The use of uncontaminated temporary pastures at least through the winter and spring and up until the lambs are sold is to be recommended. Furthermore, on high priced lands a ewe can be more cheaply pastured on annual crops sown to be grazed than on permanent grass pastures. It is readily understood from this that spring lamb production is more profitable in regions where there are large acreages of winter and spring pasture that provide an exceedingly cheap winter feed for the flock and that give ideal conditions for the growing lamb.

60. Ibid, p. 2.
Range Sheep. Formerly large bands of sheep were kept as a means of utilizing the vast areas of free grazing lands in the Plains and Mountain States. The sheep were kept primarily for their wool and were run on the open range for the entire year. The only costs were the labor costs, the camp equipment, and the investment in the sheep. This type of sheep production thrived as long as there was available large acreages of free range supplied with water. The gradual taking up of the better range land for farming purposes has forced range livestock to the poorer, rougher, and more arid regions. Sheep had an advantage under the extreme competition that developed. This was true because sheep can graze closer than cattle, can go longer without water, and can be herded more easily from the over-crowded to the less congested areas. Cattle, however, offered more severe competition as the range began to be fenced and held as private property. Cattle can be profitably handled in much smaller numbers because range sheep production can be economically run only in comparatively larger numbers. Small herds of cattle kept in connection with dry farming have rapidly displaced sheep.

Range operators have been forced to abandon the nomadic type of sheep production. In order to stay in business they have been compelled to purchase or lease sufficient land to control their range and water. They have to own improved permanent ranch property before they can use the national forests. These increased necessities of ownership, along with a possible decrease in the number of sheep per herder as caused by smaller holdings, has resulted in a greatly increased capitalization and expense per sheep. Crowded conditions make it necessary to provide winter feed.

The production of wool alone is generally unprofitable under these more intensive range practices.

Sheep ranches are pretty definitely limited to the range that is unfit for farming or for cattle ranches. Many sheep ranches are located adjacent to national forests. The necessity of cheap feed for wintering the flocks requires that there be available land suitable for hay production. Areas in which some hay can be grown but yet that are close to mountainous, arid range land or national forests contain most of the specialized sheep ranches.

Range lambs are not exceedingly fat, consequently they must be fattened or else sold at a sacrifice. The lack of suitable feeds for fattening the lambs profitably usually necessitates the shipment of the lambs into other regions. Quite often, therefore, the profit a sheep rancher receives from his operations depends upon whether the farmer farther east is willing to buy the lambs and feed them out.

**Fattening Sheep for Market.** The Corn Belt and adjacent areas, as well as many irrigated districts, have made an extensive business of fattening sheep for market. Three general systems of finishing are used: (1) Fattening in cornfields in the Corn-Belt States; (2) open yard feeding west of the Missouri River; and (3) fattening in barns in the East Central States.

The practice of fattening lambs by turning them into the cornfields and allowing them to harvest the crop is common throughout the Corn Belt. It is followed to a great extent in Iowa and northeastern Nebraska where it is the prevailing type of sheep finishing. The factors necessary for this type of

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enterprise is a supply of lambs, a surplus of corn, and fenced fields. Lambs require comparatively good fencing, but the fence needs to be no better than that required by hogs. Farmers in regions close to the central markets, such as Chicago and Omaha, where large quantities of unfinished lambs are received, normally will have no difficulty in securing lambs of the desired quality when they are wanted. The corn available for lamb feeding will depend pretty largely upon the relative prices of corn and lambs and the relative profitableness of lambs and other livestock enterprises which might utilize the corn. Labor costs on such an enterprise are low, and very little equipment is needed. The death rate, however, is usually greater than that in open yard or barn feeding. Some farmers buy lambs in late summer to clean the weeds from their corn fields.

Open yard feeding of lambs west of the Missouri River is practiced quite extensively in those regions where there is comparatively little stormy weather during the early part of the winter. Northeastern Colorado and the surrounding country in Nebraska and Kansas are the regions best adapted to such an enterprise. Here the sugar beet is the chief money crop, and alfalfa is used in the rotation. The large quantities of hay and beet tops can be profitably utilized by lambs; the manure is highly prized in helping to maintain sugar beet yields. Considerable grain is necessary to put the desired finish on the lambs.

In surplus corn regions where there is much stormy weather in the late fall and winter months such as that in the East Central States, lamb feeding is carried on in barns. Barn feeding requires more labor and equipment.

64. Ibid, pp. 260 - 261.
but it provides the farmer of this region a means of utilizing his surplus supply of winter labor. More attention given the lambs results in less death losses. The margin of profit is quite narrow because corn is much higher priced in relation to lamb prices than that farther west and because of the more intensive nature of the project. Many farmers of this area feel, however, that they can afford to feed on a very close margin for the sake of the manure. 66

Biological Factors Influencing Sheep Production. Sheep are susceptible to losses of great economic importance caused by poison plants, predatory animals, and parasites. The loco plants of the Great Plains Area from Mexico to Canada must be avoided. The death camas, plants found in the higher parts of the Great Plains area and west to the Pacific, cause considerable amounts of losses in the spring and early summer. Lupines are more widespread and cause many losses in the summer and fall months. The laurels, common in both the East and West, cause a considerable loss among sheep grazing in the eastern part of the country. Other plants, such as wild cherries, milkweeds, rayless goldenrod, Colorado rubber plant, coffee bean, and western sneezeweed, cause damage in regions where they make up an important part of the vegetation.

Wolves, coyotes, and bobcats are the greatest offenders of the predatory animals. They inflict such heavy and continuous losses as to make sheep raising an unprofitable enterprise in many localities. Such losses are common only in the mountainous and range areas. Losses from wild animals are comparatively small in the greater part of the farming regions, but predatory dogs cause severe losses throughout all of this region.

Although dogs do considerable damage to all classes of livestock, their depredations on sheep are especially severe. 68

Sheep suffer to a greater extent from animal parasites than do any other kind of livestock, but ordinarily they are but little subject to diseases caused by bacteria and viruses. The sheep scab is most common on the Southwestern range and occurs in the Central States as far south as southern Missouri and Kentucky. Most of the Southern States and the Atlantic States, except New York, are free from the disease. The sheep tick is common in all sheep producing regions but is more prevalent in the northern part of the range country. The screw worm and the various wool maggots are especially bad in the warm, humid climate of the South. 69

Internal parasites, the more common of which are the roundworms, lungworms, flukes, tapeworms, the maggot known as the grub in the head, and some microscopic forms, do considerable damage in sheep flocks. The stomach worm is the most common and important of the round worms. It is most plentiful in the South where it is favored by abundant warmth and moisture. It is also serious in the Northeastern and Middle Western States and in low, wet areas throughout the entire country. It seems to be less adapted to the high, dry, and cool areas of the Rocky Mountain region. 70

The liver fluke is common especially along the South Atlantic and Pacific coasts and the Gulf of Mexico. As the flukes require snails for an intermediate host, areas where snails are common such as wet pastures should be avoided. Gid has caused heavy losses in Montana. 71 There are several other common parasites but they are general in their location.

68. Ibid, pp. 265 - 266.
69. Ibid, pp. 266 - 267.
70. Ibid, pp. 267 - 268.
71. Ibid, pp. 268 - 269.
Factors Influencing Breeds of Sheep. The breed of sheep that will predominate in a given area depends pretty largely upon the phase of sheep production being followed and upon the physical condition of the area. There are twelve well established breeds in the United States. They can be divided into three classes each class having its own general adaptations. These breeds have been brought to fixed types adapted to the needs of their native homes.

Medium Wool Breeds. The medium-wool breeds have been bred primarily for mutton, but a good quality of fleece about midway between the length and coarseness of the long wools and the extreme fineness and density of the fine wools is also produced. The major medium-wool breeds are the Southdown, Shropshire, Hampshire, Oxford, Suffolk, Dorset, Tunis, and Cheviot. The first five are generally referred to collectively as the "down" breeds. Their home is amongst the ranges of hills or "downs" in southern England.

The Southdown sheep are more active than larger sheep, consequently they are better adapted to rolling or hilly pastures than heavier breeds. The Shropshires are noted for their excellent combination of mutton and wool production. The lambs sell as one of the most popular types to the butcher, because with liberal feeding along with their characteristic to develop in frame and flesh at the same time, they will reach market weight and finish at about weaning time. They are particularly adapted to farm conditions where feed is abundant and flocks are of moderate size.

73. Ibid, p. 3.
74. Ibid, p. 3.
The unusually large size of the Hampshire results in a lamb that has a rapid rate of growth when well fed. Breeders who wish to get lambs upon the market at an early age and who are prepared to furnish feed and care to insure this rapid growth favor the Hampshire because of this large size. This breed is not adapted to very rough or scanty pastures because of its size. The Oxfoeds are also large in size. They are well adapted to a plan of slower early growth and later finishing such as is suitable with the amount and kind of labor available in many sections devoted to mixed farming.

The Dorset was developed in a region where early lambs were desired and early breeding ewes preferred. The ewes can be bred regularly to lamb in the fall. Two crops of lambs in one year are possible. The heavy milking qualities of the ewes, combined with their early breeding habit, makes the breed particularly popular with farmers raising winter or "nouthouse" lambs for marketing from Thanksgiving to Easter. The Cheviot, a mountain breed, is accustomed to grazing over rough places. It is vigorous and hardy and capable of producing mutton upon lands unsuited to other breeds.

**Long-Wool Breeds.** The long-wools, the largest breeds of sheep, are bred chiefly for mutton. Their fleeces are open, loose, coarse, and very long. As indicated by their size, these breeds have been developed for level lands where feed can be obtained without much travel. When given the proper attention they will thrive upon lands that are too low and wet for the medium-wool breeds. They have been found to thrive in regions of excessive rainfall because the long wool will carry the water off the body.

75. Ibid, pp. 5-6.
76. Ibid, pp. 6-8.
as the close fleece will not do. Lambs of these breeds do not mature so rapidly nor fatten so young as those of other mutton breeds. Their larger size often permits the production of more weight in lambs per acre of land used for the flock than from the smaller breeds, but extra weight in lambs beyond 85 pounds usually lowers the price on the market. They are favored by only a small proportion of the farmers who raise lambs for market.

The Cotswold thrives best when not heavily stocked and prefer short pastures to luxuriant forage. They produce a good quality of long wool and were much more popular when long wool commanded a higher price than short wool. The meat is no longer liked because of its stringy nature and its high content of fat. The Lincoln breed produces a much better meat. This breed originated in a low, marshy county on the east coast of England.

Lincoln sheep require plenty of feed. The English Leicesters are good and rapid feeders and thrive on bare pastures. Lambs of this breed grow rapidly and fatten best when 12 to 15 months old. The breed is of greatest value when used for crossing, especially where grass is to be relied upon for fattening. Leicester rams and Merino ewes make a good cross. The Border Leicester is a better forager than the English Leicester, is more hardy, and can stand more exposure.

Fine-wool Breeds. The fine-wool breeds have been bred nearly altogether for wool. These sheep have the ability to stand traveling long distances for feed and water and the instinct to herd closely. These qualities have caused the exceedingly large use of fine-wool sheep on the range. The long-wools will thrive under a wide variety of conditions.

77. Ibid, p. 9.
There are three types of Merinos known as the A, B, and C types of Merinos. The body in the A and B types is considered only so far as is necessary to obtain the vigor and stamina needed to enable the sheep to produce a heavy fleece of fine wool. The C type, or Delaine Merino, is larger and less wrinkled. Some flocks of this type have considerable mutton value, and the lambs are fed to be marketed after their first shearing.

The Rambouillet sheep are the largest and strongest bodied of the fine-wool breeds. Some of the ewes have backs that are broad and fleshy enough to compare favorably with the best of the mutton sheep. Their fleeces carry less oil than the Merinos, but they are dense enough to afford ample protection from storms and low temperatures of any section.

VI. Horses.

Horses are of economic importance as a source of power and for pleasure purposes. Power uses include farm work, hauling on roads, city delivery, and saddle work. Horses kept for pleasure purposes are race horses, show-horses, and riding horses. Their individual value normally is much higher than that of the work animals. Horse breeders ultimately must depend upon one or the other of these two general horse usesages for their markets.

Place of the Horse on the Average Farm. The horse is unlike the types of farm livestock previously discussed in that it is raised for the work it will do. There are very few farms that keep a group of mares primarily for the colt that is produced. Those few that are specialized horse farms are the fancy breeding establishments which depend upon a high selling price for the surplus stock. Their overhead is exceedingly high. Those owners who are in the business for the pleasure instead of profit or those operators who have built up a very select trade and a prestige for fine horses are the only ones normally engaged in specialized horse production. Horse breeding, therefore, is done on a limited scale as a side issue to a general farming proposition.

Most any other class of livestock may occupy a major position in the business organization of the general farm as found in the United States. The average farmer keeps horses for the work they do. He is primarily interested in the production of some crop or some form of livestock that will produce directly or indirectly a consumable commodity. He may be a corn and hog farmer or a beef cattle man. The horses on his farm are kept to aid him in the production of consumption goods. He may breed horses

82. Gay, C. W., Productive Horse Husbandry, p. 179.
for either of two purposes or perhaps a combination of the two. The colts on his farm are raised to furnish replacements in the work stock and to utilize more fully the productive capacity of the mares. A small cash return is realized from the latter procedure.

If a farmer is going to keep horses to do his work, he may find it quite profitable to breed the mares he owns, providing there is available a moderately cheap source of good, nutritious feed suitable for carrying the colt until it is old enough to work. The mare can do almost as much work while in foal as otherwise. A moderate amount of work is not only harmless but positively advantageous to mares in foal. The mare can be used at the ordinary work of the farm with little or no danger of harm to her or the foal if proper care is taken. A farmer amply supplied with cheap pasture can produce a team of young work horses with very little expense in addition to the feed they consume. He may sell this team or he may keep it and sell an older team that will soon start depreciating rapidly. He cannot afford to do this, however, when the feed costs exceed the value of the colt ready to enter its place in the work of the farm. When the feed costs of raising a colt are higher than the final value of the colt, a farmer had better buy his replacements.

Prerequisites of a farm upon which colts may be produced are good brood mares and cheap feed of the right type. Colt production, as a minor enterprise supplementary to the chief farm operations, depends upon the factors that control the above mentioned prerequisites.

Necessity of Brood Mares. A brood mare of the desired type and quality is necessary before salable colts may be produced. A large number of such mares will be found only in regions where the horse is depended upon almost entirely for work stock. Some farming regions depend upon the mule as a work animal; other regions are well adapted to tractor farming. Either greatly reduces the number of mares that are kept for work and, incidentally, those available for colt production.

The horse is not so well adapted to adverse conditions as is the mule. The mule has proven to be much better suited to hot regions, to inferior care and handling, and to limited and poor quality feed. The South relies upon the mule for the major part of its power, consequently very few brood mares will be found on Southern farms. Horses make up a much greater part of the farm work-stock in the northern states. Feeds are cheaper and are of better quality; farm labor is of a higher quality. There is less extremely hot-weather work to be done in the northern part of the country. Furthermore, the mule is sure-footed and is better adapted to rough regions.

The influence of the tractor upon the production areas of horses is likewise the result of the partial exclusion of mares from areas where the tractor is adapted. A tractor may be depended upon for belt work and for draw-bar work. Farms where there is available large quantities of belt work for such jobs as threshing and feed grinding have use for a tractor. Farms lacking belt work but similar in every other respect have less use for a tractor. The tractor is primarily a time saving mechanism when used to supplement the horse for draw-bar work. It travels faster than the horse in the field and can work day and night if necessary. Horses may be used effectively in large multiple-hitch teams, but the tractor is much less difficult to handle than an eight horse team.
Tractors are more efficient on large, level fields than they are in small, irregularly shaped, and rough fields. They are especially undesirable on steep hillsides. If horses are necessary for one or more of the farm operations, it is false economy to keep the tractor for one job and the horse for another when the horse can do the work of both. Regions producing crops that may be completely tended and harvested economically without the use of horses will have more use for a tractor than those where horses must be maintained for some work unsuited to tractors. Regions where the type of farming demands a variation of the size of power units are better adapted to horse power because of the flexibility of the size of horse units from one horse on up.

The relative economy of horses and tractors depends largely upon the feed available and fuel prices as well as the amount and nature of the work to be accomplished. A farmer feeding home grown feeds has a considerably less cash power cost than the one who buys kerosene or fuel oil for a tractor. The indirect cash cost of feed, however, may be larger than the fuel cost especially if the feed can be sold in its existing form or as livestock. A tractor has a place on many livestock farms where the horse feed costs are made high by the competition of productive livestock enterprises. The actual costs of the power might be low under such circumstances, but it might be expensive to the farm as a whole because of the elimination or curtailment of more profitable livestock.

Regions where the type of farming makes necessary a variation of the size of power units from job to job are better adapted to horse power because of the flexibility of the size of horse power units from one horse up. Furthermore, horses are better adapted to small farms. There must be a sufficient amount of heavy work to justify an investment in a tractor.
A few colts are produced in regions where the tractor is the predominant source of power. At least one team of horses or mules is kept on most tractor farms. In regions where the horse is best adapted many farmers are keeping a team of mares. The mares can do the work necessary and also raise colts. Heavy work that might be injurious to the mare or her foal is done by the tractor. Theprofitableness of such a procedure will depend upon the relative horse and feed prices.

Necessity of Good, Cheap Feed. Farms producing colts must be well supplied with cheap yet highly nutritious feed. The mare will require comparatively little more feed while producing a colt than she would if not bred, but the colt will consume considerable feed before it is ready for work. It will do little or no work before it is three years old and only a small amount before it is four. The colt is growing rapidly during this period, consequently it must be fed liberally to insure a rapid, uninterrupted development.

Edmonds states that both practical experience and experimental results indicate that good, sound, rugged three-year-old colts may be most satisfactorily produced where access is had to both permanent bluegrass pastures and rotation pastures containing a considerable proportion of legumes. A winter ration that is hard to beat consists of a combination of a good legume hay and a cheaper roughage; legume hay and sheaf oats make a good combination. A good grain feed such as corn and oats, especially the latter, may be necessary to supplement the pasture and the winter ration. Excessive grain feeding, however, is expensive and entails considerable risk of depreciation from unsoundness.

84 Edmonds, J. L. and Crawford, C. W., The Farm Horse, University of Illinois, College of Agriculture and Agricultural Experiment Station, Circular No. 424, p. 25.
An area is well adapted to colt production so far as feed is concerned if it has an ample supply of good bluegrass or rotation pasture and sufficient roughage of the desired type, along with the necessary grain, to insure the desired growth. Furthermore, the competition of other livestock enterprises, such as dairy cattle and beef cattle, must be met. If livestock of a direct productive nature are well adapted to the region, the farmers may not produce colts because their available feeds may be more profitably marketed through other livestock. Dairying in particular furnishes competition that the colt producer cannot meet. Very few colts will be found in concentrated dairy regions unless there is a surplus of good pasture.

The colt must have a strong body and a well formed framework. Feeds not deficient in calcium and phosphate are desired for such development. Bluegrass regions on fertile limestone soils are noted for their horses largely because of this factor. Specialized horse farms locate in such regions to take advantage of the cheap pasture that is highly nutritious.

Mule Production. The production of mules differs very little from that of horses. The mule is a hybrid produced by a cross between a mare and a jack. The same factors that determine the regions where a mare used for colt production is found also applies for the mare producing a mule. Mule production, however, is usually south of the colt producing regions.

The mule is the major work animal in those sections where climatic conditions are most severe, feed less abundant, and horsemanship is not a prevailing art.85

Regions where such conditions are predominately, such as the South, use the mule almost exclusively as a work animal. The presence of the mule reduces proportionately the number of work mares available for colt production in such regions. The great demand for mules must come from nearby regions where there are mares. Regions suitable for horse or mule production that are close to the areas demanding the mule will have an advantage over regions farther away.

A second factor of considerable importance in the location of mule producing areas is the matter of feed. Mule colts require good feed and care if they are expected to mature into good quality mules. They require less feed than the draft horse colt largely because of their smaller size. The mature mule does well on a poorer quality feed than the horse, consequently one might expect that the mule colt will be a correspondingly easy feeder. Mule production areas, therefore, need not be so well supplied with good feeds as the horse production areas.

**Pleasure Horse Production.** The production of pleasure horses is not controlled primarily by the physical factors or the economic forces that may be present. The likes and dislikes of the people who are financially able to own horses for pleasure are largely responsible for the distribution of such horses. The early social prestige of owning fine horses that prevailed in certain communities still exists and is largely responsible for the presence of the pleasure horse.

Many pleasure horses are found near centers of outdoor recreation. A riding academy is invariably found near state or national parks, large mountain and sea shore resorts, and other corresponding recreation spots. They are also numerous around large cities.
Breeds of Horses. There are two major divisions of the breeds of horses, the draft horses and the light horses. Reese states that it is generally accepted that light horses are best suited to rolling and semi-mountainous land, while drafters are more adaptable to level country. The draft horse is used to haul heavy loads at a comparatively slow gait, usually at a walk. Power and not speed is desired. The draft horse is generally lymphatic in temperament, but he should not be too sluggish. The nature of his work requires him to be steady and easily managed, but he should perform willingly and with some snap and vigor. Regions where work of this type is common will have a great use for the draft horse.

The major draft breeds are the Percheron, Belgian, French Draft, Clydesdale, Shire, and Suffolk. There is very little difference in their adaptations to various regions. In general the Percheron is not excelled for farm work in the Corn Belt. Percherons have demonstrated ability to withstand the heat better than some of the other draft breeds, consequently they are popular in the South. Many American farmers do not like Clydesdale and Shire horses because of their extremely hairy legs.

Light horses are those horses intermediate in size between ponies and draft horses. They are well adapted to mountainous sections and where the land is rolling. They are useful for farm horse power and for riding and driving purposes in such localities.

The Arabian, Thoroughbred, Standardbred, American Saddle, Morgan, and Hackney are the chief light horse breeds. The exact breed depends pretty largely upon the fancy of the owner and the duties to be performed by the horse.

The Arabian horse is a saddle horse suited to conditions demanding considerable activity, endurance, docility, and handsome appearance. The even temperament, weight-carrying ability, and ability to withstand hardships, such as scanty food on long marches, makes this breed well adapted for cavalry use. The Thoroughbred has no peer as a running race horse. Standardbred horses, an American breed developed primarily for extreme speed at the trot and pace, have been very popular because of their versatility. They make good cavalry and light-artillery horses. American Saddle horses are well known for their easy gaits. They are used for harness, combination, and walk-trot-canter saddle horses. The Morgan horse is a general utility horse that is distributed throughout the farming sections of this country. They have won for themselves a reputation for hardiness, soundness, and usefulness. The Hackney is a heavy harness and carriage horse. They are oftentimes used for hunters and jumpers.

Breads of Mules. There are no breeds of mules because they are hybrids. Mules of different sizes and types may be expected from the different breeds of mares used in their production. Heavy draft mares will produce mules of drafty characteristics; those of the lighter breeds will produce much smaller and finer boned mules. The size and type of mule desired by the market will pretty largely determine the size and kind of mare used.

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