REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SOILS
MANILA

Soil Report 27

SOIL SURVEY OF PALAWAN PROVINCE PHILIPPINES

BY

ALFREDO BARRERA
Chief of Party

FRANCISCO G. SALAZAR AND ATANACIO SIMON
Members

WITH A DISCUSSION ON THE CHEMICAL CHARACTERISTICS AND FERTILIZER REQUIREMENTS OF THE SOILS OF PALAWAN PROVINCE

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MANILA
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FRANCISCO G. SALAZAR

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DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES

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Secretary of Agriculture and Natural Resources

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Undersecretary for Agriculture

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Undersecretary for Natural Resources

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INTRODUCTION

Agriculture is the bulwark of Philippine economy with soil as the basis. To safeguard as well as enhance the nation's economy, therefore, the conservation of our soils is of primary importance.

Soil classification is one of the foundation stones of soil conservation. Studying the physical, chemical and morphological characteristics of the soils of an area is necessary in order to properly lay the groundwork for sound and good agriculture in that particular place. Knowledge of the suitable crop or crops with the proper soil management for a certain soil comes only after the thorough study of that soil. It is only after these are known and studied could we expect a sustained economic production from the soil resources of the Philippines. With this end in view, a reconnaissance soil survey of the province of Palawan was conducted.

SOIL SURVEY OF PALAWAN PROVINCE PHILIPPINES

DESCRIPTION OF THE AREA

Location and extent.—Palawan is southwest of Manila. It lies in a NE position with the China Sea to the west and the Sulu Sea to the east. Puerto Princesa, the capital and chief seaport on the east coast, is approximately 363 nautical miles from Manila. Palawan is the fourth largest province in the Philippines with an area of 1,474,570 hectares. Aside from the main island of Palawan, the province includes about 200 other smaller islands and islets, the most important ones being Busuanga, Culion, Linapacan, etc., of the Calamianes Group; and Cuyo, Dumaran, Cagayanes and Balabac Islands. Palawan mainland is a long and narrow island, about 425 kilometers long; approximately 40 kilometers at its widest portion (Brooke's Point); and, about 8.5 kilometers at its narrowest section (Baheli).

The soil coverage of the province in 1946 was:

Type of cover	*Area in hectares*	*Per cent*
Commercial forest	1,050,190	71.2
Non-commercial forest	258,154	17.5
Cultivated land	19,671	1.3
Open land	106,607	7.2
Swamps	39,948	2.8
Total	1,474,570	100.0

Relief and drainage.—The mainland of Palawan is traversed lengthwise by a chain of mountain ranges. Mount Mantalingahan is the highest peak in the south with 2,086 meters elevation; Mount Gantung in central Palawan rises 1,788 meters; and in the north, the most prominent is the Cleopatra Needle Peak which is 1,585 meters high. There are short rivers and numerous streams throughout the province. Emptying into Saint Paul Bay is the famous subterranean river. This river is reputed to be about seven kilometers long flowing under limestone mountains.

From the northern end of Palawan to about 10 kilometers inland the terrain is rolling to hilly, after which high mountains begin to rise centrally traversing farther south to the municipality of Taytay. Few pockets of level to nearly level land exist in this section of the province. Along Taytay Bay on the east coast and Malampaya Sound on the west coast are swampy

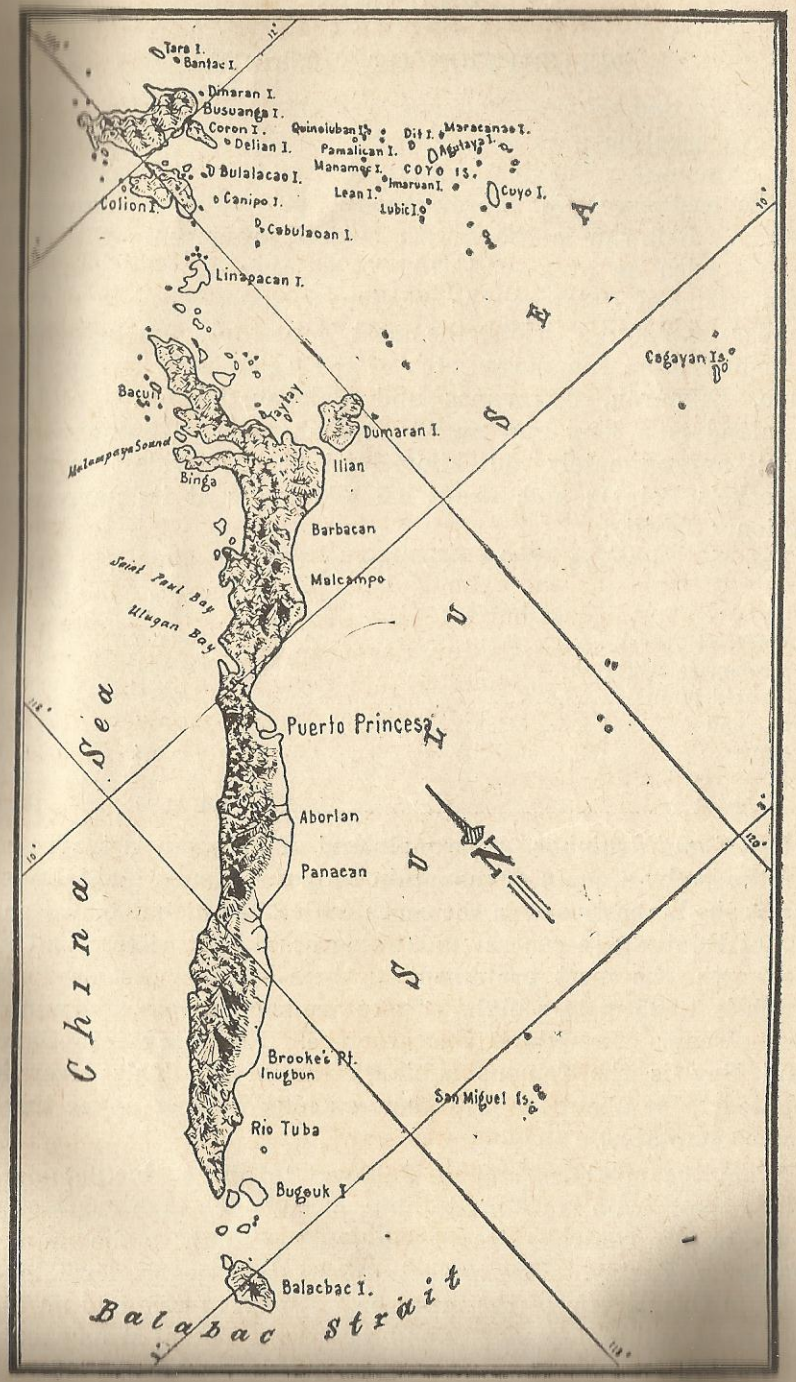

FIG. 2. The relief map and drainage pattern of Palawan Province

areas. South of Imuruan Bay the chain of mountain ranges run endlessly throughout the length of the island to about 30 kilometers from the southern most tip of the island. Practically, no coastal plain exists on the western side of the province except probably very narrow ones lying along the coast.

The eastern side or Sulu Sea coast is comparatively less rugged than the western coast. Among the mountains and hills flanking the Dumaran Channel and fronting Green Island Bay on the northeast coast are three valleys separated from one another by ranges of hills.

Ilian Valley, the northern most of the valleys, is drained by the Ilian River. The valley forms from about the mid-section of the island and extends toward the coast running in a northwest direction.

The Barbacan Valley lies in a north-south direction. Roughly, it occupies an area which starts from inland at about the mid-section of the island and extends down to the coast. The valley is narrow at the coast but becomes wider towards the interior. The valley is drained by the Barbacan River and its many tributaries. This river empties into Green Island Bay.

The southern and most extensive of the three valleys is the one drained by the Caramay River. This valley encompasses Rizal and del Pilar barrios.

South of these valleys the coast again becomes mountainous, broken only by mangrove swamps northeast and southwest of Puerto Princesa. The region directly north of the provincial capital and the remaining east coast to the south are a series of narrow beaches, level to nearly level coastal plains, small valley floors, swamps, mildly rolling to strongly rolling terrain, hills and low mountains. The most important plain in this section is at Panacan and Brooke's Point. There are several rivers and creeks draining this plain. This coastal plain begins from the municipality of Aborlan, extends southward beyond the barrio of Panacan, and westward, it reaches the edge of the central chain of mountain ranges or about seven to ten kilometers from the coast.

The eastern coast has many deep landlocked bays and harbors with depths reaching 20 fathoms. These bays and harbors are protected from storms and influence of strong currents and big waves of the Sulu Sea. The western harbors of the islands are bordered with dangerous coral reefs.

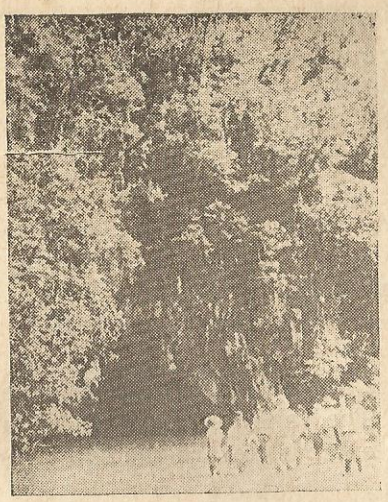

FIG. 3. One of the famous spots in Palawan is the underground river located in Saint Paul Bay. Picture shows the entrance of the river estimated to be about 7 kilometers under the limestone hills.

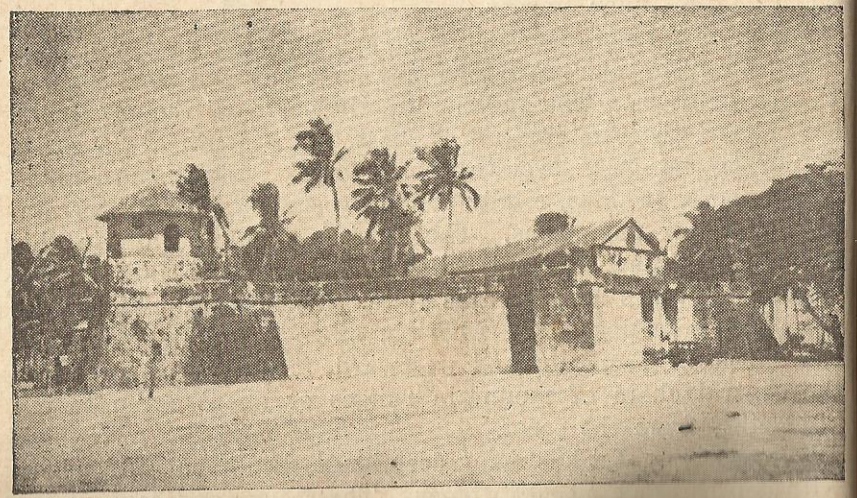

FIG. 4. The Spanish fortress in Cuyo, once the stronghold of Spanish colonizers, was used to protect the island from Moro piracy. Similar fort is found in Taytay.

PLATE 1

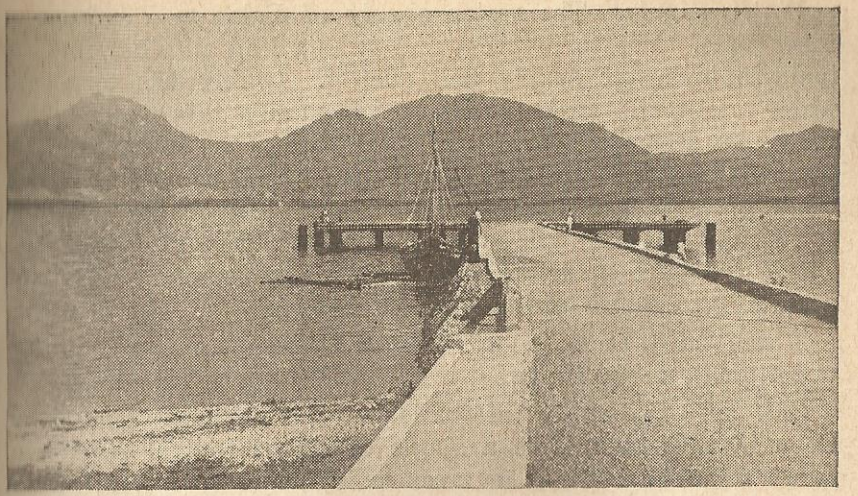

FIG. 5. This is the port at Puerto Princesa. It is ideally located and well protected from strong winds. The presence of shoals and rock islets, however, offer danger to navigation.

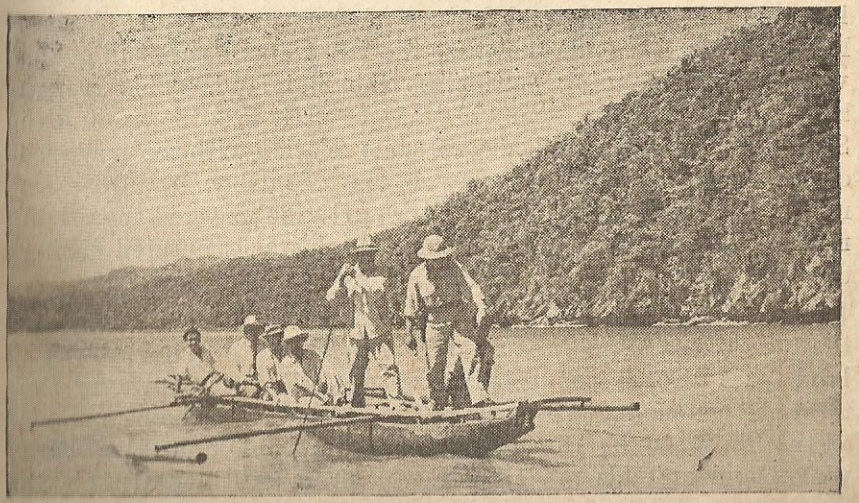

FIG. 6. The western coasts do not have as good bays as those of Puerto Princesa. Landings have to be done with banca. The shores are shallow and the hillsides descend to the shores directly.

PLATE 2

Water supply.—The water supply of Palawan Province is inadequate. Puerto Princesa and Iwahig lead all other municipalities in water supply and quality. Iwahig has excellent water resources. Water is obtained from mountain streams and from two deep wells with depths of more than 400 feet. The total estimated capacity is about 36,000 gallons per day. In other parts of the province water supply and quality is rated from poor to fair, all sources of which require treatment. The census figures for Palawan Province water supply classified according to source are shown in table 1.

Moves have been started toward the improvement of the water facilities in Palawan.

Geology.—The outline of the island of Palawan is similar to Cebu in that both have a single dominant central mountain range with short rivers or river valleys, and narrow fringing coastal plains. Unlike Cebu, however, Palawan has good natural harbors formed by recent drowning of fair size river valleys such as the Malampaya Sound, Ulugan Bay, and Puerto Princesa.

The depths of the sea bottoms around the island of Palawan are very irregular offering great hazards to navigation. Sand bars, coral reefs, as well as big rocks that are barely visible at low tide mark the general feature of the seas around Palawan. Nevertheless, a trough known as the Palawan Deep exists in the western part running parallel to the mainland. This trough has a depth ranging from 100 to 1,500 fathoms. According to Smith, this trough would suggest some relation with the existence either of faulting or that Palawan, Cuyo, Balabac, and Mindoro represents the high points along a partly submerged mountain range. It was calculated that this trough was generated during the late Pleistocene and Recent.[1]

According to Smith,[2] it has been definitely known that during the Pleistocene period, the area from Mindoro to Palawan was a land mass directly connected to Borneo. This is shown by the total and complete distinctions of these lands from the remainder of the Philippines. During this period of land connection, both plants and animals made their way from continental Asia to Palawan and Mindoro. Smith cited Worcester, who in 1898

[1] The Genozoic Era (Recent life) is divided into epochs in the order from the earliest Eocene, Oligocene, Moicene, Pliocene, to Pleistocene or Recent.

[2] Smith, Warren D. Geology and Mineral Resources of the Philippines, Bureau of Science Pub. 19. Bureau of Printing, Manila (1924).

TABLE 1.—Number of families obtaining its water supply from various sources—Con.

Total number of families	Water pipe system		Artesian Well			Surface Well		Rain Water tank		Other Sources	
	No. of families	% of total families	No. of Wells	No. of families	% of total families	No. of families	% of total families	No. of families	% of total families	No. of families	% of total families
21,353	1,540	7.2	4	37	0.2	11,366	53.2	6,524	30.6	1,886	8.8

has shown that zoologically, the connection between Mindoro and Palawan was very close with that of Borneo. Likewise, Dickerson's [1] survey revealed the presence of forty-eight endemic species of birds in Palawan only which exhibit strong Indo-Malayan element. Among the amphibians, the order Apoda of the family Caeciliidae is restricted to Palawan, Borneo, and the Sulu Archipelago. This species requires definite land connection for its dispersal. The presence of Cyprinidae (fresh water minows) in Palawan was only possible during the time when the southern end of China Sea had land, and a great river flowed northward draining western Borneo and Sumatra. There was unquestionably, Dickerson continued, a migration of Bornean and Malaysian types into Balabac, Palawan, and the Calamianes as indicated by the mouse dear (Tragulus) found in Balabac only; the pangolin or scaly anteater (Manis) only in Palawan and Culion; the slow porcupine (Thecurus) only in the Calamianes Islands, Palawan and Balabac; the squirrels (Sciurus and Nannosciurus) only in Palawan and Culion and some in Sulu and Basilan; the mongooses (mungos) only in Palawan and Culion; the binturong (Arctictis) only in Palawan; the weasel (Mustela) only in Palawan and Sulu; the clawless otter (Aonyx) only in Palawan; and the so-called skunks (Mydaus) only in Balabac, Palawan and the Calamianes group during the Pleistocene Epoch. Merrill also pointed out that Bornean flora is found in Palawan and the west side of Mindoro but does not cross to Luzon. Of these two islands, Mindoro is less strictly Bornean with more endemic species, both plants and animals, than what Palawan possesses. This is definitely shown by the unique timarau (*Bubalus mindorensis* Heude) which is found only in Mindoro. This dwarf water buffalo is a distinct Asian type developed during the early Pleistocene or from the late Pliocene ancestor. That Mindoro first separated from Palawan before Palawan was separated from Borneo is shown by the isolation of this animal in Mindoro. Later there were separation and apparently other reconnections between Borneo and Palawan and the Calamian Group which did not extend to Mindoro. This was indicated by the presence of several species of plants which are found in Palawan only but are absent in Mindoro. Palaeogeographic studies have placed the present separation of Palawan from Borneo to a very late Pleistocene.

[1] Dickerson, Roy E. 1928. Distribution of Life in the Philippines. Bureau of Science Publication No. 21.

Coron is wholly a limestone island whose coastal shores rise vertically to form high and steep cliffs. It is very sparsely inhabited and uncultivated. The soil is very shallow and much eroded and the whole land is astruted with limestone needles. Busuanga Island is a very hilly country whose rocks consist chiefly of cherts. The soil is likewise very thin, generally poor, and much eroded. The island is very rich in manganese of which seven mining companies once operated before the war. Culion is the site of the largest leper colony in the world. This island is also very hilly with poor and very acidic soils. According to Smith, the geological structure of Culion is similar to that of Busuanga.

Siliceous rocks and quartzites similar to those found in the Calamianes Group are also found in the northern part of Palawan particularly in Bacuit and Taytay. The soils in this region are also similar to that of Busuanga. Many islets dotting the western coast of Bacuit are of limestone formation whose landscape are very similar to that of Coron. Little is known of the volcanoes of Palawan. Although volcanic rocks are found in this island, McCaskey is of the opinion that volcanic activity in Palawan had been incidental rather than as cause of the origin of this big land mass. Chert rocks dominate the mountainous western coast from Taytay to Alfonso XIII. The soils developed from this formation are very shallow and oftentimes much eroded. Trees are dwarf in size. From Alfonso XIII the rocks change to limestone which was classified to be of the Malumbang formation. This formation extends down to Pagoda Hill to the south. Rugged and much dissected, its soil nevertheless is a rich, black, and deep clay. The whole western part of the mainland is very sparsely populated. Only the small and narrow fringing coastal plains are planted mostly to coconuts wherein one of the largest plantations in Palawan is found.

Vegetation.—The vegetative cover of Palawan is one of its distinctions in the sense that most forms of fauna and flora of this island are different from the rest of the Philippines. This difference has been attributed to the geological formation of Palawan. Evidences have shown that land connection with Borneo existed which did not extend to Luzon. During this period of land connection migration of both plants and animals took place. An example is the absence of *lauan* trees in the entire province which is abundant in the forest of the rest of the Philippines. In fauna, there is the so-called mouse-deers,

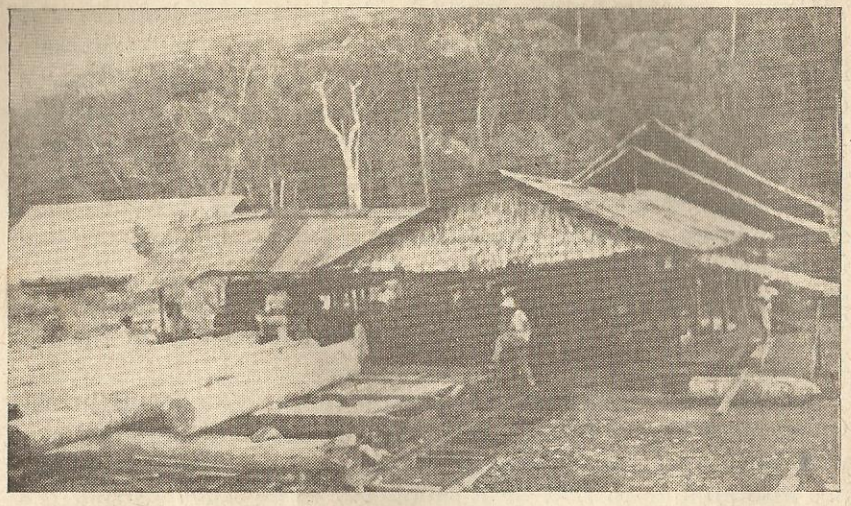

FIG. 7. Many species of hard woods are found in the forests of Palawan. Lumbering is quite an important industry, but it is not yet fully well developed.

FIG. 8. *Almaciga*, also known as Manila copal, is a kind of resin extracted from *almaciga* (*Agathis philippinensis*).

PLATE 3

porcupines and skunks, which are found only in Palawan. *Sika* (*Calamus spinifolius* Becc.) is a species of rattan found only in this province. This rattan has straight and long internodes.

Mainly attributed to the kind of soil formation, only thick primary forests are found in Aboabo, Baheli, and in Ilian. The soils in these places are deep and fairly fertile. In these areas, *apitong, malugay, akle, calantas* (*Toona calantas* Merr. and Rolfe species of wood for making cigar boxes), *almaciga, marango, ipil,* and *paina* (*Kingiodendron alternifolium* (Elm.) Merr. and Rolfe) are found. However, in the rest of the island of Palawan the soil generally is shallow and very low in fertility with the result that the forest stand is thin. In these areas are most of the hardwoods of Palawan. The forest here is characterized by its thin stand and not much understory. Where the soil is poor, shallow, and partly dry, the hardwood trees like *urong* (*Fagraea cochinchinensis* (Lour.) A. Chev.) are famous for their hardness and great durability when used as post. Even in wet grounds, post of this kind of wood was reported to last for hundred years without any visible sign of decay. *Palo de hiero* or *mankono* or the "Iron tree" (*Xanthostemon verdugonianus* Naves) is well known tree in Culion and Busuanga. The wood is so hard that it defies bolos or axes.

In many open areas where the soil is clayey and oftenly wet, cogon and *talahib* are the common grasses. *Bangkal* is the kind of tree in such areas. *Lantana* are common in the dry soils of the plains. Wild cashew trees are plentiful specially at Busuanga, Culion and in the mainland.

In the marshy and mangrove areas, all kinds of halophytic plants are found. Chief among these are the *bakauan* trees which stand nearly 20 meters high. The trees do not commonly branch. In many areas specially in the northwestern coast a variety of palm called *anibong* (*Oncosperma tigillaria* (Jack) Ridl.) which grow in brackish water swamps are used for posts in fish corals.

Organization and population.—The organization and growth of the province of Palawan may be subdivided into five stages, namely, Mohammedan or pre-Spanish influence, Spanish rule, American regime, the Philippine Commonwealth Government, and finally the Philippine Republic.

The Palawan mainland and its surrounding islands were among the first within the Philippine Archipelago to come under Mohammedan influence that took place from the 13th to the 15th century.

After the Mohammedan influx, the Spaniards came and established their foothold on the Calamianes Group. The island of Palawan during that period was then called island of Paragua. Subsequently, this group of islands was organized into a province and called Calamianes Province which became a part of the Philippines under Spanish sovereignty. The large island of Paragua and all other smaller islands south of it belonged to the Sultanate of Borneo. In the early part of the 18th century, the Spaniards attempted to extend their rule southward over the island of Paragua by setting up a garrison at Taytay on the northeastern part of the island. The Spaniards successfully maintained this garrison and eventually Taytay became a Spanish fort large enough to hold 700 men. With this, Taytay and northern Paragua came under Spanish domination. Taytay became Catholicism's advanced post into a Mohammedan frontier. Two Moro attempts, one in 1730 and another in 1735, to drive out the Spaniards from Paragua by capturing Taytay were staged but failed in both tries. About 1750, the Spanish government was eventually able to extend its rule and authority over southern Paragua when the Sultanate of Borneo ceded same to Spain. Spanish domination over southern Paragua was not so successful as that in the north because of fever outbreaks among the colonizers and members of the expeditionary forces sent by the Spaniards. It was in 1858 that Calamianes Province was divided into two provinces, namely, Castilla Province and Asturias Province. Castilla comprised the Calamianes Group and other adjacent islands together with the northern portion of the island of Paragua. Its capital was at Taytay. Asturias covered the rest of Paragua and the island of Balabac with Puerto Princesa as the capital. Later, the island of Balabac was made into a separate politico-military province under the name of Principe Alfonso. Later, Asturias was reorganized and the boundaries of Calamianes Province were modified which finally became a single politico-military province with Puerto Princesa as capital. Thus, at the close of the Spanish rule in the Philippines, the group of islands from Calamianes on the north to Balabac Island on the south was divided into three district politico-military provinces, namely, Calamianes, Paragua, and Balabac.

In 1896 when the Philippine Revolution broke out a great number of Filipinos suspected of complicity in the uprising were banished by the Spanish authorities to the settlement of Balabac.

During the American regime, civil government was established in Paragua on June 23, 1902. At the start, the provincial capital was located at Cuyo on Cuyo Island but was eventually moved to Puerto Princesa. In 1905, Paragua Province was renamed to Palawan.

Before the Moros came to Palawan, the inhabitants of the region were the native Palawanos, the Bataks and the Tagbanuas. The natives roamed here and there, but when the Moros came and settled on the southern shores of Balabac the natives were forced to stay north. As the Spanish influence began to be felt over their islands the natives slowly and gradually moved into the interior where we find them to the present. During the Spanish regime the most important settlements were Taytay, Puerto Princesa, Coron, Culion, Cuyo, and Balabac. The lesser ones were Dumaran, Cagayancillo, and Agutaya.

The rise in population and townships in the province are shown as follows:

	1918	1938	1948
Population	69,989	93,673	106,269
Person per sq. km.	5	6	7
No. of municipalities	9	–	12

At present there are 12 municipalities; namely, Aborlan, Agutaya, Bacuit, Balabac, Brooke's Point, Cagayancillo, Coron, Culion, Cuyo, Dumaran, Puerto Princesa, and Taytay.

Transportation and market.—Palawan Province has approximately only 231 kilometers of surfaced roads. The island of Palawan is served by about 174 kilometers of roads; 155 or 67 per cent of the entire total is located on the eastern side of Palawan Island, northward and southward from the provincial capital. The road southward from Puerto Princesa connects the capital with Panacan through Aborlan covering a distance of about 98 kilometers. Northward, Puerto Princesa is linked with the barrio of Babuyan by a 57 kilometer span of surface road. In northern Palawan a highway about 19 kilometers or 8.4 per cent of the provincial total joins the town of Taytay on the east coast with one of its barrios, Pancol, on the west coast. The remaining 57 kilometers are distributed among three outlying islands: 12 kilometers or 4.9 per cent on Culion Island, 33 kilometers or 14.8 per cent on Busuanga Island, and 12 kilometers or 4.9 per cent on Cuyo Island.

By class of roads Palawan Province has:

1st class	17.5 km.	7.5%
2nd class	157.1 km.	68.0%
3rd class	56.8 km.	24.5%

Puerto Princesa is undoubtedly the center of population of the province and is, therefore, the chief local market where farmers sell their farm and livestock products. The capital is also the chief seaport of the province and deals commercially with the ports of Manila and Iloilo. Taytay in the north is the seaport for that region. Cuyo town on Cuyo Island and Culion on Culion Island have a small port each which deals to a limited extent with the ports of Manila and Iloilo. On Balabac Island, an island southwest of and separated from the island of Palawan by the Balabac Strait, is the town of Balabac. This seaport town trades with the Spice Island and Borneo. Other ports in the province with 3rd class rating are Aborlan and Panacan on the eastern coast of Palawan Island. Brooke's Point on the southeastern coast; Coron, Busuanga Is.; and Halsey, Culion Island also have ports with 3rd class rating.

The western coast of Palawan Island can have little or no sea trade at all because this coast is bordered with coral reefs. Off-shore anchorage, however, can be found at Bacuit Bay, Imuruan Bay, and Malampaya Sound.

The Philippine Air Lines, Inc. maintains scheduled weekly flights between Manila and del Pilar (Barbacan) and between Manila and Puerto Princesa.

Education.—The development in educational pursuit of the province can be judged from the following table:

	1918	1939	1946
Enrollment—			
Elementary —	4,493	8,247	10,864
High School —		370	332
Number of teachers			178
Number of schools—			
Primary	32		
Elementary	2		114
High School	2		2

Diseases.—The most prevalent kind of disease in Palawan is malaria. It is very common especially in the mainland. According to the Bureau of Health the sub-tertian is the most prevalent type but benign tertian is also common and quartan

occurs to a minor degree. The subtertian malaria is usually of the celebral type and is often complicated with pneumonia. This is prevalent from Puerto Princesa and southwards to Brooke's Point. The area from Barbacan, Puerto Princesa and Panacan is classified as from moderate to endemic in malaria, which has up to 45 per cent cases of the disease. The area around Brooke's Point and southward is classed as hyperendemic, or the occurrence is more than 50 per cent of malaria among the inhabitants.

The non-Christian tribes such as the Palawanos, Bataks, and Tagbanuas are partly immune to this disease but they harbor the parasites in their blood system and are carriers of the disease.

Next to malaria, *yaws* prevail with more cases among the non-Christians than with the Christians. This disease, which is due mostly to mal-nutrition, responds readily to treatment by injections.

As of March, 1946 the province of Palawan has two government-operated hospitals. These two hospitals have a combined bed capacity of 46.

Reputed as one of the largest in the world is the Culion Leper Colony located in the island of Culion. The reservation is 460 square miles. In 1940, there were 3,728 male lepers and 1,744 female lepers. In addition are non-Christian lepers numbering 121 males and 30 females. Most of the lepers sent to Culion come from Cebu, Leyte, Iloilo, Bohol, and Ilocos Sur.

Industries.—The bulk of the population of the province is engaged in farming. Rice, corn, coconut, sugar cane, native tobacco, cassava, and banana are the important crops raised. The island of Cuyo has good citrus stands, and oranges are shipped to Manila and other neighboring provinces.

Outside of farming, fishing leads all other industries in the province. The island of Palawan and the other outlying islands of the province are all surrounded by veritable fishing grounds, like Malampaya Sound, one of the richest in the whole archipelago. Fish like *tanigue, ronpecuado, sabalo* (large bangos), *lapu-lapu,* mackerels, and *banags* are some of the species that abound in the seas adjacent to Palawan. The yearly gross of fish caught by the different methods is about 300,000 to 400,000 kilograms valued at P80,000 to P90,000. Deep sea fishing with trawl and modern equipment is new or undeveloped. The coral

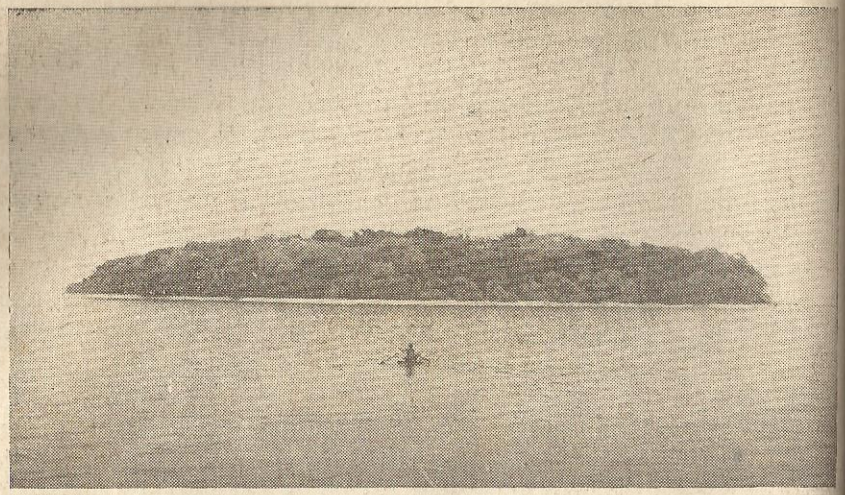

FIG. 9. This is Ursula or Birds' Island, east of Bugsuk Island, one of the hundreds of islands composing the province. As the name suggests, it is the sanctuary of many species of birds.

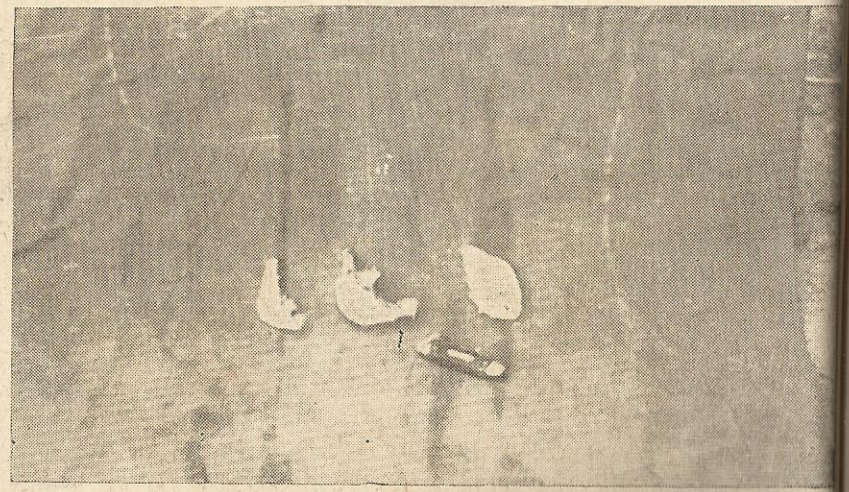

FIG. 10. The edible birds' nest. It is produced by birds inhabiting cliff in Bacuit and Taytay. The gathering and selling of this nest constitute a fairly good seized industry.

PLATE 4

FIG. 11. The waters surrounding the many islands of Palawan are rich in fish. Fishing is a major industry of the province. Above are milkfish caught by dynamiting, a method leading to the extinction of the industry.

FIG. 12. These shells called *Samong* are gathered mostly from the waters south of the mainland. The shells are used for the manufacture of buttons.

PLATE 5

system, nets, hook and line, and spears are extensively used in the industry. People permanently living along the shores are engaged in year-round fishing with possibly some of them taking up other kinds of occupation during the slack or off-season and when the seas are rough to augment their income. Fish caught in Palawan have many ready markets especially in northern Mindanao and Manila. There are those that are channeled to the local markets for provincial consumption. Closely connected to fishing is the dried fish industry and the collection of such sea products like *trepang, samong,* and other species of shells for button-making all of which are shipped to Manila. In addition, the seas around Palawan also teem with turtles, squids, and big clams.

Coconut trees are grown in the province, but these are confined along the shores. Compared to other provinces with long shore lines, however, Palawan's copra industry is not so extensive or fully developed. The copra industry in Palawan contributes much to the economy of the province.

Palawan Province is well covered by commercial forest. In 1949 there were about 40 forestry concessioners in the province with area concessions ranging from one to 43,000 hectares. The allowable cut from these concessions ranged from 5 to 45,150 cubic meters. The Malampaya Lumber Venture, Inc. has the biggest lumber concession and is located at Malampaya, Taytay. Other big lumber concessions are located at Kadipangan River to Durudeen Point, Aborlan; Aguada Pt. to Culasian River, Brooke's Point; Tagburos to Bacuñgan River, Puerto Princesa; Guinaratan to Malcampo River, Puerto Princesa; and Caruray to Komdong, Puerto Princesa. Lumber and logs are mostly shipped to Manila, and belong to the first and second class groups; namely, *akle, apitong, ipil, malugay,* and *bangkal.* There are little less than 200 forestry establishments with an aggregate total number of employees reaching 1,000 persons. The gross sale of products is almost ₱1,000,000 annually. The products aside from lumber and logs are rattan, beeswax, resins, and the barks of some trees for tanning leather. The *sika* variety of rattan, which is in great demand, is only found in the forests of Palawan. Non-Christians who are well acquainted with forest trails are the chief collectors of *almaciga* which they sell to dealers at ₱0.20 to ₱0.30 a kilo.

FIG. 13. Many soils even on plains in the eastern shores of Palawan, like in Ilian and Barbacan, were developed from poor materials of the uplands.

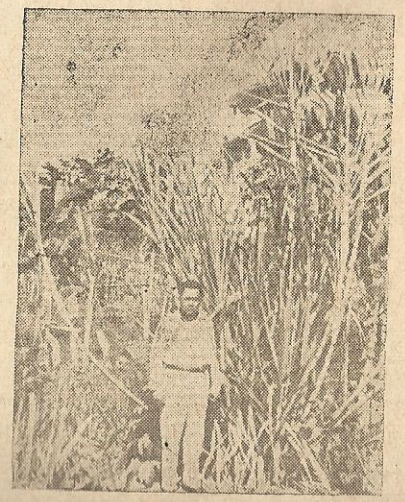

FIG. 14. This crop of sugar cane grown in the plain of Apoaporauan on Quingua soil is good judging from its size and growth. Governor Abueg stands beside it.

PLATE 6

According to geologic studies and prospectors' reports, mineral resources of the province are many and varied, like mercury, iron, sulphur, gold, manganese, lead, antimony, quartz, and copper. Copper has been discovered but unexploited. Figures from the Yearbook of Philippine Statistics: 1946 lists 6 companies in Palawan Province operating manganese mines with total assets of over half a million pesos. The Palawan Silica Mines operates a concession in Del Pilar and mines about 36,000 tons of sand a year for the San Miguel Bottle Factory in Manila. Silica sand from this area was found to be high grade material for bottle manufacture. At the rate of 36,000 tons of silica sand a year, it is reported that the area may still be good for another 100 years.

CLIMATE

Climate is predominantly responsible for the classes of fauna and flora that thrive naturally in any part of the globe. Climate determines or delimits the kinds of agricultural crops which can be grown economically and profitably in any given place. In effect, therefore, climate is of primary significance to agriculture. There are numerous climatic factors of hydrologic and agricultural significance. Such elements of climate like temperature, water supply (precipitation), humidity, sunshine, cloudiness, light, wind storms, salt spray are interrelated in their influence on plant and animal life.

Plant is a complicated organism, affected by nutritional and climatic environment with all their effects jointly favorably or adversely influencing plant response. The risk in farming will be considerably minimized and precarious economic returns of living from the soil can be more or less stabilized if only a farmer can, in some way, predict with a certain degree of accuracy what weather conditions will be for the coming year, an ensuing season, or even a month in advance. The quality of produce especially of vegetables is a direct effect, and the ravages of insects and plant diseases like defoliation diseases or fruit and root troubles are the indirect effects of weather to quality.

The climate of an area is the summation of weather from day to day, and weather is a day-by-day break-down of the climate. Meteorologists, therefore, are concerned with the daily weather while climatologists concentrate on the longer time range.

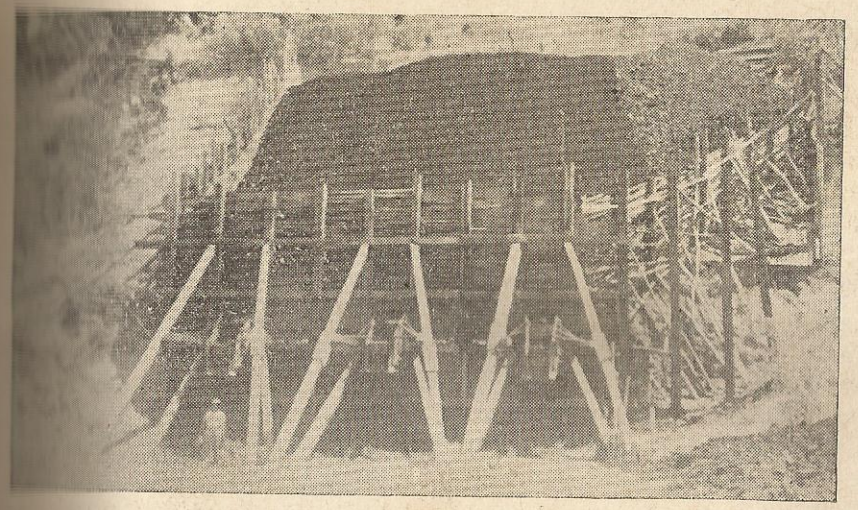

Fig. 15. Manganese are plentiful in Busuanga Island. There are several mining claims in this island but only a few are operated.

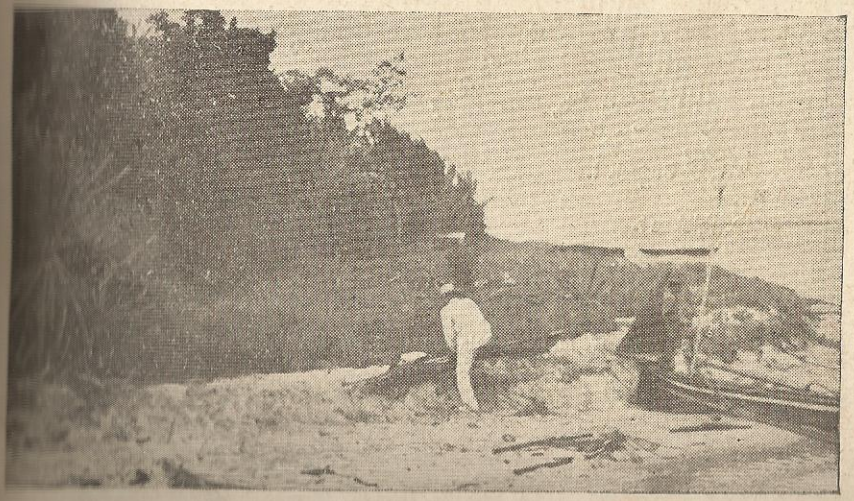

Fig. 16. Silica mine in Del Pilar in the northern shores of Palawan is operated by the San Miguel firm. The sand along the shores are hauled to Manila where they are crystalized into glass.

PLATE 7

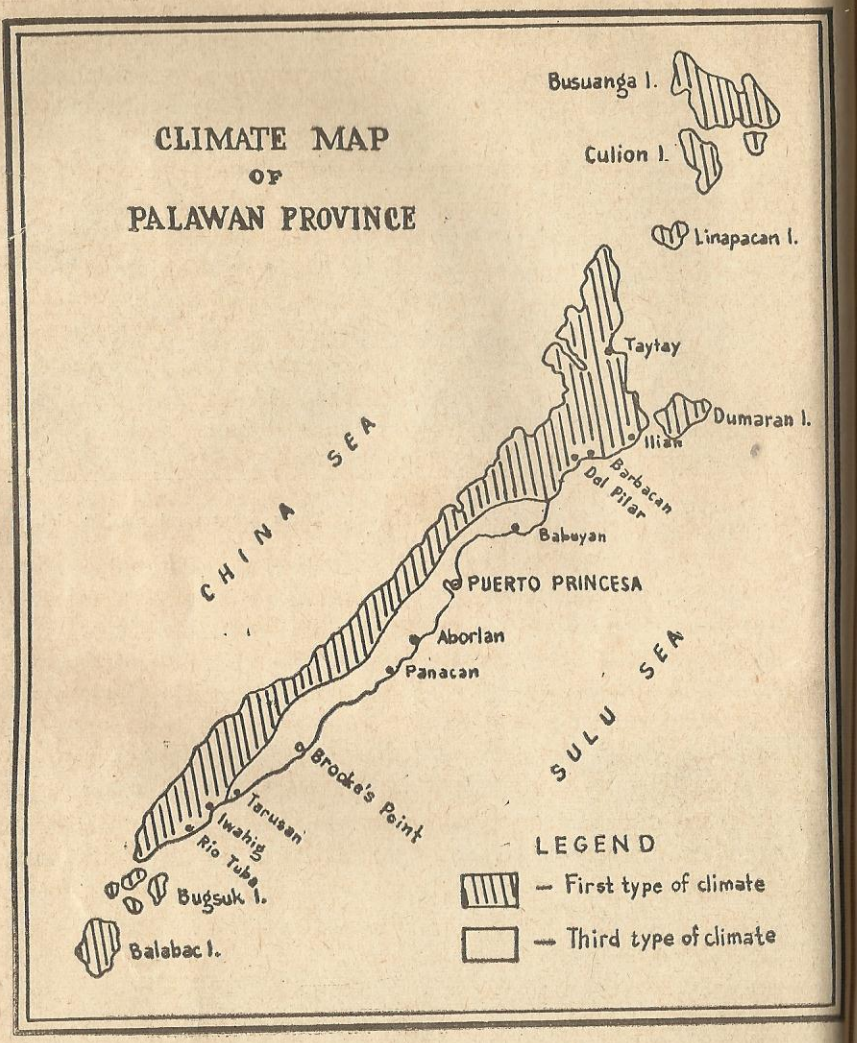

FIG. 17. Map of Palawan showing distribution of rainfall.

Rainfall.—There are two types of climate prevailing in the province. The first has two distinct seasons, six months dry and six months wet; the third type is characterized by a short dry season of from one to three or four months with no pronounced rain period.

The northern and southern extremities of Palawan including the whole of the western side are classified under the first type. These areas are represented by weather data from Cuyo and Culion. These areas record five months dry period from December to April. The highest recorded rainfall occurs in July. The Weather Bureau considers a month dry if the precipitation recorded is 50 millimeters or less. A month with more than 50 millimeters of recorded rainfall may also be considered dry if the preceding month has a low record.

Records of the weather stations at Iwahig Penal Colony, Puerto Princesa and Brooke's Point are presented in table 2 to cover areas under the third type of climate. With the exception of Iwahig Penal Colony these records are the average for nine years. Iwahig Penal Colony data on average monthly rainfall are based on a period of 30 years.

The data from these stations indicate that eastern Palawan has a short dry season with no pronounced rain period. Four comparatively dry months are recorded during January through April. At Brooke's Point the rainiest month is December; at Iwahig it is November; and, at Puerto Princesa it is September.

Eastern Palawan falls under the third type of climate but some inhabitants claim the area has a distinct dry and wet season, or first type of climate.

Precipitation is the most important factor in determining plant and crop distribution within locales of almost similar or equal temperature conditions. The soil classes and types with their inherent native fertility are important factors in determining the variety and adaptability of agricultural products such as vegetable crops of high economic value, but still weather and the resultant water supply have first to be reckoned with in the determination of the suitability of these soils.

Temperature.—The temperature of Palawan is uniformly high. Table 4 gives the monthly average temperature in three different weather stations in the province. There is no marked difference in temperature between areas falling under the first and third types of climate. Generally, the warmest months

TABLE 2. *The average monthly and annual rainfall, and the monthly average number of rainy days in Palawan Province* *

Month	First type of climate				Third type of climate					
	Stations				Stations					
	Culion 12 years		Cuyo 47 years		Brooke's Point 9 years		Iwahig Penal Col. 30 years		Puerto Princesa 9 years	
	Ave. mo. rainfall (inches)	No. of rainy days, mo. ave.	Ave. mo. rainfall (inches)	No. of rainy days, mo. ave.	Ave. mo. rainfall (inches)	No. of rainy days, mo. ave.	Ave. mo. rainfall (inches)	No. of rainy days, mo. ave.	Ave. mo. rainfall (inches)	No. of rainy days, mo. ave.
January	1.13	4	0.60	2	2.04	5	2.32	6	1.44	4
February	0.75	2	0.32	1	1.34	4	1.30	4	0.60	3
March	0.44	3	0.28	1	2.80	5	1.61	6	2.38	4
April	2.07	4	1.11	3	2.47	6	2.09	6	1.37	4
May	8.15	15	7.93	14	4.88	10	6.62	15	5.04	11
June	13.81	20	12.92	20	6.40	15	7.79	18	6.30	13
July	26.37	24	16.26	23	5.74	13	8.69	19	7.08	14
August	23.77	22	14.84	21	7.09	16	7.67	17	7.14	15
September	20.38	22	14.65	21	5.28	14	9.47	19	8.86	16
October	11.47	17	11.15	17	5.81	13	10.52	20	7.61	18
November	10.00	10	6.06	8	6.23	14	10.81	16	8.66	16
December	3.97	7	3.04	5	7.96	11	9.28	11	4.85	10
Annual	122.31	150	89.16	136	58.04	126	78.17	157	61.33	128

* Data from: Weather Bureau. Monthly average rainfall and rainy days in the Philippines. Weather Bureau, Manila, 1956.

TABLE 3.—*The monthly mean, mean maximum, and mean minimum temperature, and the humidity in the different stations in Palawan* *

Station	Coron					Cuyo					Puerto Princesa				
	Temperature (°F)			Relative Humidity-%		Temperature (°F)			Relative Humidity-%		Temperature (°F)			Relative Humidity-%	
Month 1954	Mean	Mean Max.	Mean Min.	Mean	Normal 5 years	Mean	Mean Max.	Mean Min.	Mean	Normal 5 years	Mean	Mean Max.	Mean Min.	Mean	Normal 5 years
January	82.0	90.0	73.9	82	78	81.9	85.8	78.0	83	80	81.4	88.9	73.9	84	86
February	82.2	90.1	74.3	82	74	82.2	86.9	77.4	82	80	82.2	90.1	74.3	82	84
March	83.4	91.1	75.6	80	74	82.3	87.1	77.5	84	79	81.2	87.9	74.4	84	82
April	85.2	93.1	77.4	75	74	84.6	90.7	78.5	81	77	83.0	90.3	75.8	84	81
May	84.2	90.7	77.8	78	81	83.8	89.6	78.0	86	80	82.2	88.5	76.0	87	82
June	81.9	88.2	75.6	82	86	82.2	88.3	76.7	80	83	81.5	87.6	75.4	88	86
July	81.2	88.0	74.5	86	88	82.0	88.6	75.3	88	84	81.0	87.7	74.4	88	86
August	80.9	86.9	74.9	87	88	81.6	87.1	76.1	88	83	80.8	87.4	74.2	88	86
September	79.4	84.9	73.8	89	88	80.8	86.1	75.4	87	84	80.0	86.2	73.8	88	87
October	81.1	88.1	74.1	86	87	81.6	87.8	75.4	86	83	81.0	87.9	74.2	87	86
November	80.1	86.7	73.5	85	83	81.3	85.8	76.8	83	81	80.4	87.4	73.5	87	85
December	80.3	87.1	73.5	78	81	80.4	83.7	77.1	83	81	80.4	86.8	73.9	86	87
Annual	81.8	88.7	74.9	82	82	82.1	87.3	76.8	84	81	81.3	88.1	74.5	86	85

* Data from: Weather Bureau. Annual climatological review, 1954. Weather Bureau, Manila, 1956.

TABLE 4.—*The monthly average temperature (°F) in the different stations in Palawan* *

Month	Coron 6 years	Cuyo 22 years	Puerto Princesa 5 years
January	81.0	80.4	80.4
February	81.4	80.6	80.9
March	82.5	82.2	81.5
April	84.8	84.1	83.4
May	84.0	83.7	83.0
June	81.8	82.2	81.1
July	81.0	81.4	80.9
August	80.6	81.2	81.0
September	80.7	81.1	80.8
October	81.5	81.6	81.2
November	81.4	81.7	80.9
December	80.4	81.1	80.0
Annual	81.8	81.8	81.3

* Data from: WEATHER BUREAU. Monthly average temperature in the Philippines. Weather Bureau, Manila, 1956.

are March, April, and May; the coolest are December, January, and February. Table 4 data are based on monthly average temperature observations for a period of five or more years.

Temperature is one of the three most important factors in climate as far as plant growth is concerned. In other words, temperature, moisture, and light are the big three that exert most power and influence over plant life. Temperature influences every chemical and physical process connected with plants such as solubility of minerals; absorption of water, gases, etc.; synthesis; growth; and, reproduction. In truck gardening temperature requirements of the different varieties have much to do with the planting calendar of the farmer. The adaptability of certain crop varieties; their subsequent stages of growth; bulbing, harvesting and curing are all dependent on temperature.

In the animal world, atmospheric temperatures have profound effect in the reproductive as well as productive efficiency of livestock, like milk production in dairy farming. Observation of Rhoad in Brazil showed that purebred European dairy cattle imported into the tropics produced, on balanced rations, only 56 per cent of their apparent capacity. Further studies showed that development of heat tolerance, heat resisting ability, greatly improved dairy type of cattle adaptable to tropical climatic conditions.

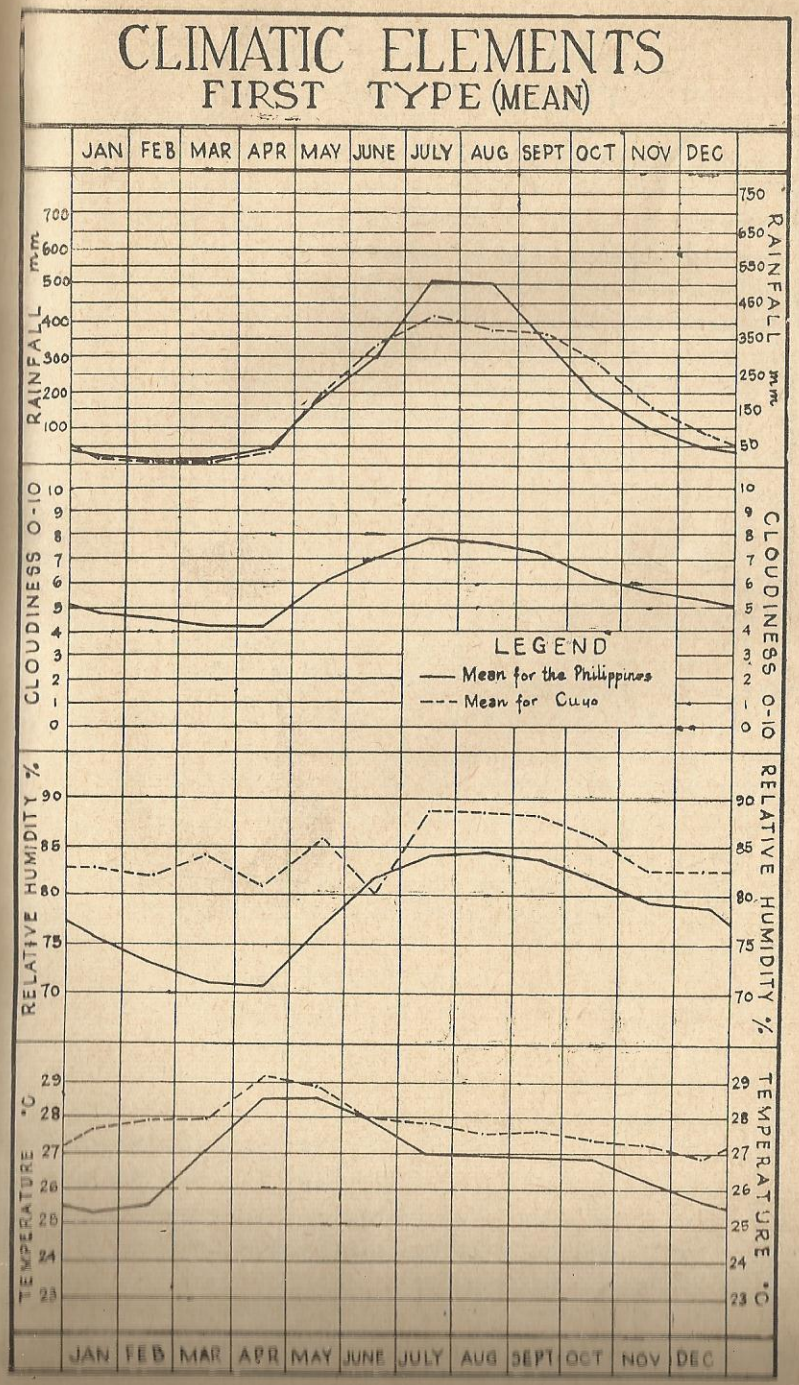

FIG. 18. Graph showing monthly climatic elements for the Philippines and Cuyo

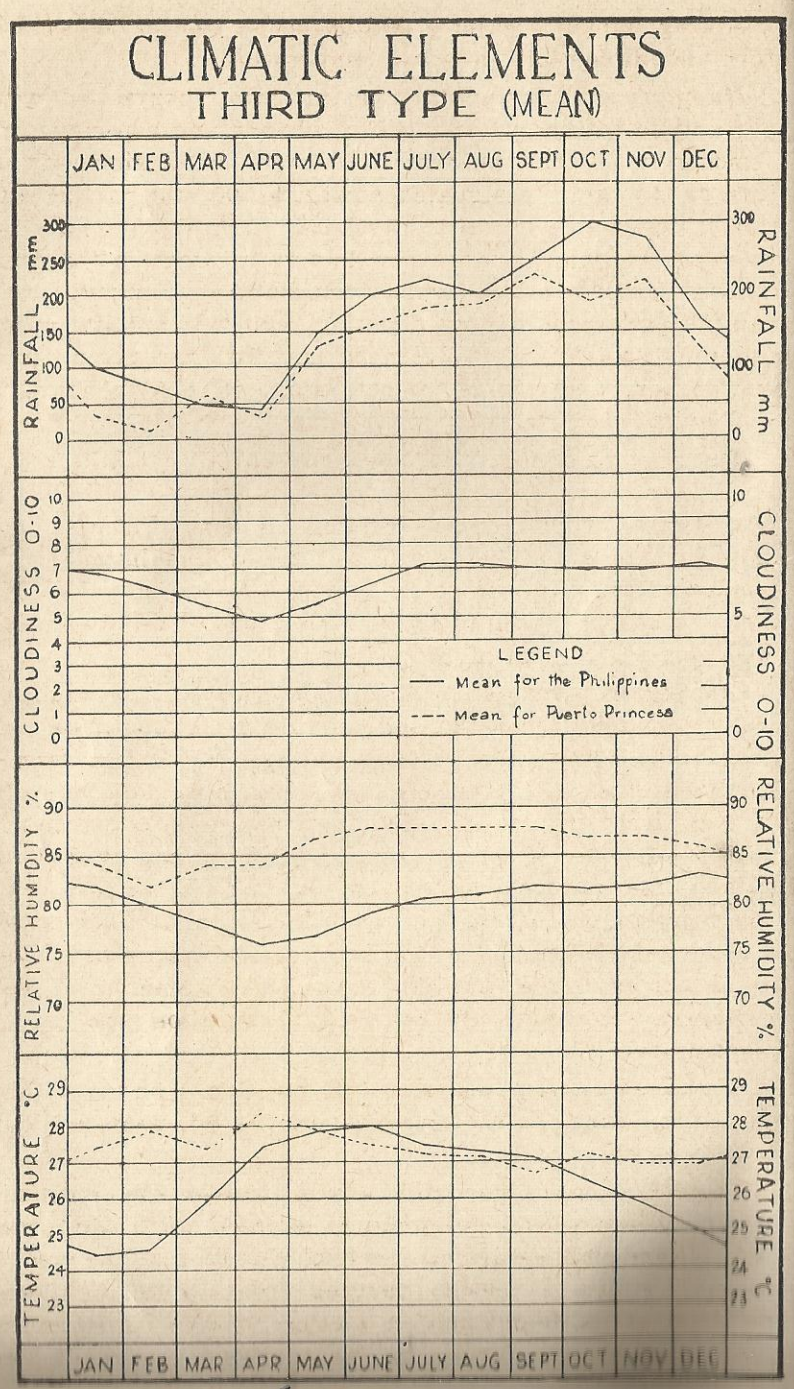

Fig. 19. Graph showing monthly climatic elements for the Philippines and Puerto Princesa.

Among humans, activity limitations as well as physical comfort and discomfort go with temperature.

Humidity.—The dampness or moderate degree of wetness perceptible to the eye or touch of objects and especially of the atmosphere is called humidity. Complete saturation with moisture of the air is designated *humidity* 100 and partial saturation is designated by lesser numbers. Relative humidity is the ratio of the quantity of vapor actually present to the greatest amount possible at the given temperature. Temperature and rainfall are major factors affecting relative humidity, although the intensity of these two climatic elements may not necessarily and decisively determine the percentage of relative humidity in any given place for any given time.

The relative humidity of two representative weather stations in Palawan are presented as a set of figures in table 3 as well as in graphic representation. Puerto Princesa has a more or less uniformed as well as high relative humidity. The range is from 80 to 88 per cent with a mean annual of 86 per cent. Cuyo has an 80 to 88 per cent range of relative humidity with a mean annual of 84 per cent.

One of the principal conditions determining the quantity of water removed from the soil surface by evaporation is the relative humidity of the atmosphere. Water lost from the surface in this way is surely and appreciably very large to be of practical importance. Fluctuations in relative humidity affects the rate of evaporation in such a way that if other factors like moisture content of soil and its temperature and the temperature of the air were momentarily held constant, a lower relative humidity tends to enhance vaporization, while in an extreme case, wherein the relative humidity of the atmosphere approaches 100 per cent, evaporation may cease and condensation induced.

Winds.—Palawan lies in a NE position. The two distinct prevailing winds in the province are the NE monsoon and the SW monsoon.

The NE monsoon generally sets in October and continues till April. The monsoon blows mainly between north and northeast with a tendency towards an easterly direction at the end of the season. It has a velocity ranging from 15 to 25 kilometers per hour at its height and an average of 5 to 7 kilometers per hour. Raineloud during the NE monsoon practically lose all

their moisture before reaching the southwestern part of the archipelago, thus Palawan receives no rainfall at this time.

The SW or summer monsoon follows the NE monsoon after a transition period of variable winds and calms. The SW monsoon prevails from June to October. It blows most steadily during July and August although not as steady as the NE monsoon, reaching a maximum velocity of about 35 kilometers per hour and an average of 3 kilometers per hour. In October or during the close of the SW monsoon, strong winds occur in the southern part of the province. The southwest winds bring torrential rains but with an uneven distribution.

The NE and SW monsoons affect the eastern and western parts of Palawan. When these winds blow the seas are very rough. The calm months of the year are from April through June on both the eastern and western sides of Palawan. During these months sea travel is very favorable.

Typhoons.—In Palawan typhoons are not very frequent. Typhoons average about once a year. Only seven significant typhoons occurred in northern Palawan between 1903 to 1918. While northern Palawan may have persistent gales, heavy squalls and torrential rains, the southern part is practically free of typhoons.

AGRICULTURE

The sub-topics under this topic are; namely, (1) crops, (2) agricultural practices, (3) livestock and poultry industry, (4) farm tenure, and (5) types of farm. The actual observations and first-hand information gathered during the reconnaissance soil survey of Palawan Province about its agriculture are augmented in this report by statistics compiled by the Bureau of the Census and Statistics.

CROPS

In terms of financial returns the most important crop of Palawan is coconut. In the census of 1948, from the reports of 5,154 coconut farms or 42.9 per cent of all farms in the province, there were 7,525.88 hectares planted to coconut trees. This hectarage represents about 33.8 per cent of cultivated land in the province. In that year 756,598 trees were accounted for of which 596,834 were bearing trees. Tabulated hereunder is a comprehensive data on this crop as gathered in the 1948 census:

1. Total number of trees:		
a. Bearing	596,834	trees
b. Tapped for *tuba*	2,965	trees
c. Non-bearing	156,799	trees
Total	756,598	trees
2. Production of nuts for various purposes:		
a. For food	1,653,690	nuts
b. Sold as nuts	201,871	nuts
c. For making copra	20,719,060	nuts
d. For making home-made oil	171,538	nuts
Total	22,746,159	nuts
3. Production of:		
a. Copra	5,178,664	kilos
b. Home-made oil	16,772	liters
c. Tuba	726,995	liters

The estimated value of the above products was ₱1,359,819.

Upland rice culture is more predominant than the planting of lowland rice. In 1948 there were 6,454.15 hectares planted to upland rice which represents about 29 per cent of total cultivated land in the province. The leading upland rice variety is *Pindinga* which yields about five cavans of palay per ganta of seed or about 65 cavans of palay per hectare. The other upland rice varieties are *Sipango* which produces from three to five cavans of palay for every ganta of seed or about 40 to 65 cavans of palay per hectare, and *Binirao* which when planted in May and harvested in September yields about 60 cavans of palay per hectare. It must be borne in mind, however, that these fairly high yields were obtained from newly opened land. The estimated value of lowland and upland rice for 1948 was ₱1,486,748. The area planted to lowland rice, first crop, was reported to be 1,308.78 hectare which is about 5.9 per cent of cultivated land. From this hectarage 28,132 cavans of palay were harvested, an average of 21 cavans of palay per hectare. The production was valued at ₱328,707 for the first crop, while a second crop on 146.28 hectares producing 2,954 cavans of palay was valued at ₱33,305. Of the 1,308.75 hectares in 1948, about 435 hectares were irrigated and the rest unirrigated. Due to inadequate irrigation facilities only about 67 hectares can be re-planted with benefits of irrigation and the rest from the reported 146.78 hectares cultivated under a second crop go without an assured supply of water.

A total of 175.51 hectares were cultivated to sugar cane in 1948. This area is about 0.8 per cent of cultivated land in the province. There were 248 farms or 2.1 per cent of all farms reported raising this crop. Their production was 9,225.1 tons of sugar cane with an approximate value of ₱389,417. Sugar cane is made into muscovado sugar, *basi* (fermented cane juice), as well as consumed for chewing.

There were 4,373 farms which reported cultivating cassava. This number is 36.4 per cent of all farms and covers 1,759.6 hectares which is 7.9 per cent of cultivated land in Palawan. The production amount to more than five million kilograms and was worth a little less than half a million pesos. Cassava is a staple food among the non-Christian tribes as well as Christian settlers in the interior.

Corn is another staple food crop of the people of Palawan. There were as many as 1,571 farms reported raising this crop with an aggregate area of 974.49 hectares, first crop; 56 reported farms with a total of 28.59 hectares, second crop; and, 67 reported farms with a total of 24.39 hectares, third crop. The yearly production is 16,148 cavans valued at ₱162,366. Next to rice, corn is the most important food crop of the people especially to those in the inland settlements. Generally there are two crops a year, but in some cases three crops are raised. Corn is usually interplanted with rice or tobacco. In newly opened *kaingin* the average production is as high as 30 cavans per hectare. In areas already depleted of soil fertility the average goes as low as 12 cavans per hectare.

Tabulated in tables 5 and 6 are vegetable and fruit crops of Palawan. Statistically presented, the reader may have a better grasp of the horticultural potential of the province as well as a better view and knowledge of the diversified crops, the soils and climate of Palawan are capable of growing economically and profitably.

AGRICULTURAL PRACTICES

Like the majority of provinces in the country, Palawan has been and still is predominantly agricultural. Unlike most other provinces, however, progress in farming practices, from the primitive to the scientific methods, has been rather slow. The nomadic farming practices during the advent of Mohammedans into the province have carried through Spanish domination, American occupation, and up to this day and age have not yet been completely obliterated. Only during the last two decades have enterprising people from Luzon and other Visayan Islands in appreciable numbers been immigrating to Palawan. Most of the new inhabitants have either been landless or share croppers in their former places. It was inevitable and as to be expected these people retained or continued practicing the same methods used in the farms they left, which for certain

TABLE 5.—*Vegetable crops raised in Palawan, area planted in hectares, total production and value* [1]

Vegetable crop	Area planted (ha.)	Total production (Units)	Value in Pesos
Tomato	86.49	18,083 kilos	4,551.00
Gabi	66.54	139,900 kilos	15,371.00
Squash	57.63	107,228 fruits	24,333.00
Beans	50.67		
1) Singapore beans	18.26	8,515 kilos [2]	2,479.00
2) Soy beans	4.30	1,543 kilos [3]	1,194.00
3) Bountiful beans	2.05	1,600 kilos [3]	1,407.00
4) All other beans	26.06	12,641 kilos [3]	7,430.00
Ubi	48.66	54,894 kilos	9,856.00
Eggplant	37.99	38,712 kilos	7,762.00
Pineapple	35.87	54,720 fruits	4,765.00
Watermelon	26.86	14,353 fruits	4,058.00
Mungo	16.86	4,370 kilos	2,530.00
Arrowroot	13.74	18,459 kilos	3,281.00
Ampalaya	12.92	10,785 kilos	2,078.00
Peanuts	8.98	3,606 kilos	1,923.00
Upo	7.99	39,911 kilos	6,770.00
Garlic	7.69	6,215 kilos	7,458.00
Ginger	7.23	3,355 kilos	1,909.00
Pechay	6.20	26,859 kilos	5,385.00

[1] Data from Census of the Philippines: 1948
[2] Green beans
[3] Dry beans

TABLE 6.—*Fruits raised in Palawan, number of bearing trees, total production, and value* [1]

Fruit crop	Number of bearing trees	Total Production	
		Quantity-units	Value in Pesos
Banana	473,334 hills	583,429 bunches	407,732.00
Chico	10,135 trees	10,026,763 kilos	350,937.00
Mango	7,226 trees	2,658,089 fruits	154,280.00
Calmito	5,260 trees	5,094,405 fruits	101,785.00
Jackfruit	14,857 trees	260,942 fruits	92,202.00
Papaya	24,434 trees	798,309 kilos	63,509.00
Cashew	19,235 trees	6,405,442 kilos	31,641.00
Kalamansi	4,226 trees	5,480,015 fruits	29,482.00
Tamarind	787 trees	6,432 *kaings*	20,908.00
Orange	3,247 trees	364,770 fruits	18,757.00
Mandarin	1,381 trees	230,314 fruits	12,336.00
Sugar-apple	8,708 trees	341,364 fruits	11,615.00
Pumelo	789 trees	130,703 fruits	11,411.00
Durian	185 trees	92,970 kilos	11,156.00
Coffee	3,271 trees	4,709 kilos	5,347.00

[1] Data from Census of the Philippines: 1948

were not modern or scientific in nature. These immigrants are the present small landowners or share croppers in the province. It can be seen in the tabulation hereunder that small farms comprise the majority of farm holdings in Palawan:

Size of farm (ha.)	No. of Farms 1939	No. of Farms 1948
Less than 1 ha.	6,085	4,151
1—less than 2 ha.	2,513	3,544
2—less than 3 ha.	837	1,307
3—less than 4 ha.	410	535
4—less than 5 ha.	254	348
5—less than 10 ha.	513	1,059
10—less than 20 ha.	436	622
20 ha. and over	256	444
Total	11,304	12,010

In such a set up farmers produce their own needs. Mechanization, contour strip cropping, crop rotation, contouring and terracing, fertilizing and liming, if done at all, are only practiced where the size of farm and financial ability of the farmer so warrant. In other words few farms exceeding 20 hectares were found doing accepted methods of conservation farming. In fairness, however, to most farm owners in the province, the distance of the province from commercial centers coupled with the fact that water and air transportation to and from Palawan are not so adequate and frequent enough, plus the inadequacy of highways and feeder roads in the province contribute to the retardation of progressive-scientific farming in Palawan. Provincial and national officials and some inhabitants themselves, interested as they are in the advancement of agriculture in Palawan, are hampered also by other factors, primarily indirect in nature, but just as detrimental. Health conditions in the province are not so favorable. Elsewhere in this report is a discussion of diseases in the province. Agricultural instruction needs intensification and stepping up. Again, health and agricultural extension are thwarted by lack of or inadequacy of transportation and communication. Another setback the farmers encounter is labor supply. Shortage of farm hands is especially felt during rice planting and harvesting. During harvest time when there are not enough men to hire the share of harvesters is one part for every three or four parts of rice harvested. In extreme cases the share of harvesters is hiked to one half. With the proximity of many farms to forests and uncleared areas farmers also have to protect their crops from

wild pigs, innumerable rats, monkeys and rice bugs, aside from having to protect themselves from poisonous snakes which are prevalent.

Like most hilly and mountainous provinces, Palawan has a fair share of *kaingin* farming. From year to year virgin land is cleared which is seldom used for the next season. Clearing are comparatively small as each farmer is only capable of working an area which needs more or less 20 gantas of seed. People who open *kaingins* in the mainland are not only confined among the natives or inhabitants but others like people of Cuyo Island. These itenerant farmers go to the Palawan mainland in March returning only to their homes in September after the harvest season.

LIVESTOCK AND POULTRY INDUSTRY

The livestock industry of Palawan is not so well developed. The extent, availability and good quality of land for pastures in the mainland and outlaying islands of the province warrant the expansion of the industry. There are several owners of cattle ranches in the Panacan and Rio Tuba areas. However, during the reconnaissance soil survey of the province it was observed that the cattle were loose and wild. Carabaos are also raised and are kept mainly as work animals. Carabao milk, however, contribute, to some extent, to the economy of the inhabitants. Other animals raised are swine, horses, goats, and sheep.

TABLE 7.—*Number and value of livestock on farms of Palawan Province; 1939, 1948*[1]

Livestock	1939		1948	
	Number	Value	Number	Value
Carabao	14,244	₱219,368	9,090	₱772,650
Cattle	38,048	281,619	18,640	876,080
Horses	981	13,613	708	39,755
Swine	8,897	45,095	9,961	240,007
Goats	1,023	2,273	710	7,810
Sheep	42	168	30	210

[1] Data from Yearbook of Philippine Statistics: 1946; and, Summary Report on the 1948 Census of Agriculture.

Incidental to the livestock industry is the production of milk. From the 1948 Philippine census, 4,616 liters of milk was the total provincial output; of this quantity 4,352 liters were

furnished by carabaos, 220 liters by cattle, and 44 liters by goats. The estimated total value of this dairy product was ₱1,384.00 or an average of ₱0.30 per liter.

Of the 12,010 farms that were recorded in the 1948 census, only 12 were livestock farms, or 0.1 per cent of all farms, while two were poultry farms which is less than 0.1 per cent of all farms. The estimated worth of the poultry industry for that census year was ₱120,419. From out of this value, chicken is about 97.5 per cent of the total worth, ducks about 2.1 per cent, geese, turkey and others the remaining 0.4 per cent. Chicken eggs from the same census report were worth about ₱121,563.

TABLE 8.—*Number and value of poultry on farms of Palawan Province; 1939, 1945 and 1948*

Poultry	1939 [a] Number	1945 [a] Number	1948 [b] Number	1948 [b] Value
Chicken	133,393	44,450	164,848	₱117,579
Ducks	980	330	1,830	2,560
Geese	113	40	90	150
Turkey	67	20	20	130

[a] Data from Yearbook of Philippine Statistics: 1946.

[b] Data from Facts and Figures about the Economic and Social Conditions of the Philippines, 1948–1949.

FARM TENURE

Under this topic, farmers or farm ownership are divided into four classes, namely: (1) full owners, (2) part owners, (3) tenants, and (4) farm managers. The third class of farmers, tenants, is subdivided into (*a*) share tenants, (*b*) share-cash tenants, (*c*) cash tenants, and a generalized sub-classification (*d*) other tenants. This is the scheme of classification used by the Bureau of the Census and Statistics in differentiating farms by tenure of farm operator throughout the Philippines which will also be used in this report. The basis of this classification was on the proprietary relationship of the farmer to the land he cultivates, and upon the system of paying rent when the land belongs to another.

In the census year of 1939 with a reported area of farms totalling 90,551.41 hectares, the cultivated land area was only 19,670.93 hectares or 21.7 per cent of the whole total. After World War II the number of farms in the province increased

TABLE 9.—*Number and area of farms in Palawan Province by tenure of farm operator; 1939 and 1948*

Farm operated by	1939 [a] Number	1939 [a] Area (ha.)	1948 [b] Number	1948 [b] Area (ha.)
Full owners	10,844	43,449.95	11,024	40,534.98
Part owners	60	711.85	374	578.89
Tenants				
a) Share	387	1,976.51	161	948.23
b) Share-cash			3	193.00
c) Cash			5	20.71
d) Other tenants			385	3,712.00
Farm managers	13	44,413.10	58	7,796.44
Total	11,304	90,551.41	12,010	53,784.25

[a] Data from Yearbook of Philippine Statistics, 1946

[b] Data from Summary Report on the 1948 Census of Agriculture

from 11,304 to 12,010, but the total area covered decreased from 90,551.41 to only 53,784.25 hectares. It is worthy to note, however, that the cultivated area increased from 19,670.93 to 22,258.38 hectares, or 41.4 per cent of the total farm area. The rate of increase from 21.7 to 41.4 per cent may be attributed directly to the combined efforts of bureaus and offices under the Department of Agriculture and Natural Resources, notably the Bureau of Lands, Bureau of Forestry, Bureau of Agricultural Extension, and the Bureau of Soil Conservation; to the efforts of the Land Tenure Administration, National Resettlement and Rehabilitation Administration, Agricultural Tenancy Commission; indirectly by the Department of Public Works and Communication, Department of Health, Department of Education and other government entities; much less to say the efforts of local and provincial officials.

TYPES OF FARM

The type of farm classification is based on the relationship between the area planted to a particular crop and the area of cultivated land on the farm. This method subdivides farms into twelve groups, namely: (1) palay, (2) corn, (3) abaca, (4) sugar cane, (5) coconut, (6) tobacco, (7) vegetable, (8) fruit, (9) root crops; the 10th type is livestock farm; the 11th is poultry farm; and a 12th type, other farms. In the Bureau of the Census and Statistics method, a farm is classified palay farm if the area planted to palay (first crop lowland, or upland) is 50 per cent or more of the cultivated area in that specified farm. Livestock farms to be classified as such should

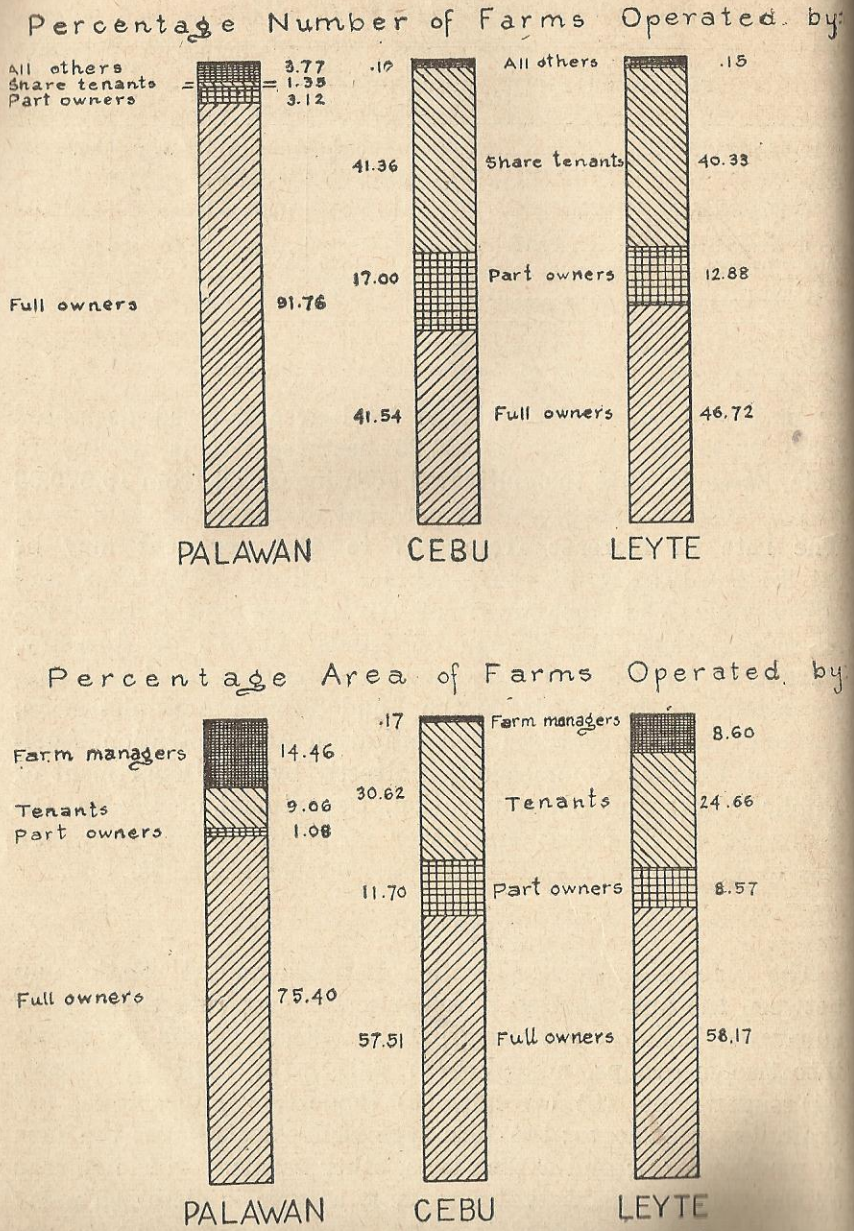

FIG. 20. Chart showing the proportionate number of farmers and area cultivated for the different types of farm tenure.

have an area of 10 hectares or more, more than 10 heads of cattle, carabaos, horses, goats, and sheep, and less than 20 per cent of the total farm area is used for the raising of crops, fruits and nuts. Poultry farms are those with more than 300 chickens or 200 ducks and usually less than two hectares of cultivated land. "Other farms" are those which could not be classified under any of the aforementioned groups.

The different types of farms in the province as of 1948 according to the Bureau of the Census and Statistics are tabulated hereunder:

Type of farm	*Number of farms*	*Percentage Distribution*
Palay	7,444	61.99
Corn	146	1.21
Abaca	9	.07
Sugar cane	3	.03
Coconut	1,675	13.95
Tobacco	3	.03
Vegetable	4	.03
Fruit	159	1.32
Root crops	193	1.61
Livestock	12	.10
Poultry	2	.01
Other	2,360	19.65
	12,010	100.00

SOIL SURVEY METHODS AND DEFINITIONS

Soil survey is an institution devoted to the study of the soil in its natural habitat. It consists primarily of (1) the determination of the morphological characteristics of soils, (2) grouping and classifying them into individual units according to their characteristics, (3) their delineation on the map, and (4) the description of their characteristics in reference to the growth of plants and their relationship to agriculture and other activities of man.

The soils, their landscapes and underlying formations are examined systematically in as many locations as possible. Borings with the soil auger are made, test pits are dug, and exposures such as those found in road and railroad cuts are studied. Each excavation, road or railroad cut, exposes a series of layers or horizons called collectively the soil profile. These horizons of the profile as well as the parent material beneath this profile are studied in detail and the color, structure, poro-

sity, consistency, texture, and organic matter content, roots, gravels, and stones are noted carefully. The reaction of the soil and its contents of lime and salts are determined by simple tests. The drainage, both external and internal, and many other external features such as relief of the land, climate, and natural and artificial cultures, are taken into consideration, and the relationship of the soil and the vegetation and other environmental features are studied.

On the basis of both the external and internal characteristics, the soils are grouped into classification units, of which the two principal ones are (1) soil series and (2) type. A *phase* (3) of a soil type is defined on the basis of soil characteristics that are of importance in land-use. When two or more of these principal mapping units are in such intimate or mixed pattern that they cannot be clearly shown on a small scale soil map, they are mapped or grouped into a (4) complex. Areas that have no true soil, such as river beds, coastal beaches, or bare rocky mountainsides are called (5) miscellaneous land types. Areas that are inaccessible like mountains and great forest lands, and whose classification is of no agricultural importance for the present, are classified as undifferentiated soils.

A *series* is a group of soils that have the same genetic horizons, similar important morphological characteristics and similar parent material. It comprises soils having essentially the same general color, structure, consistency, range of relief, natural drainage condition and other important external and internal characteristics. In the establishment of a series, a geographic name is selected, usually that of the locality where the soil was first identified. For example, the Brooke's series was first found and classified in the vicinity of Brooke's Point in the southern part of Palawan.

A soil series has one or more soil types, defined according to the texture of the upper part of the soil, or the surface soil. The class name, such as sand, loamy sand, sandy loam, silt loam, silty clay loam, clay loam, or clay is added to the series name to give the complete name of the soil. For example, Brooke's clay loam is a soil type of Brooke's series. The soil type, therefore, has the same general characteristics as the soil series, except for the texture of the surface soil. The soil type is the principal unit of mapping. Because of certain specific characteristics, it is usually the unit to which agronomic data are definitely related.

A *phase* of a soil type is a variation within the type, differing from the soil type only in some minor features, generally external, that may be of special practical significance. Differences in relief, stoniness, and extent or degree of erosion are shown in phases. A minor difference in relief may cause a change in agricultural operation or in the kind of machinery to be used. The phase of a type with a slight degree of accelerated erosion may present different fertilizer requirements and other cultural management practices that are different from those of the real soil type. A phase of a type due mainly to degree of erosion, degree of slope, and amount of gravel and stones on the surface soil is usually segregated on the map if the area can be delineated.

A *soil complex* is a soil association composed of such intimate mixtures of series, types, or phases that cannot be indicated separately on a small scale map. This is mapped as a unit and is called a *complex*. If in an area there are several series such as Sara, Sta. Rita, Alimodian and others that are mixed together, the two dominant series must bear the name of the complex, as Sara-Santa Rita complex or Sara-Alimodian complex, as the case may be. If there is only one dominant constituent, that series or type bears the name of the complex as Sara complex or Alimodian complex.

Surface and subsoil samples for chemical and physical analysis are collected from each soil type or phase, the number being determined by the importance and extent of such soil type or phase. Profile samples are also obtained for further morphological studies of important soil types.

The soil survey party, usually composed of two or three soils men, maps the area and delineates the various soil types, phases, complexes, and miscellaneous land types. All natural and cultural features found in the area are indicated on the soil map. These are trails, roads, railroads, bridges, telephone and telegraph lines, barrios, towns, cities, rivers and lakes, prominent mountains, and many others.

SOILS OF PALAWAN

Soil consists of disintegrated and chemically altered rock material, mixed with varying percentages of organic matter. Changes in the soil, physical, chemical, and biological are continuous. For this reason soil is said to be dynamic and a complex substance. From the original rock through decom-

position the soil formed may be measured in terms of these changes as young, mature, or old. Since the operation of soil-forming agencies and their results are not uniform, soils vary from place to place and, therefore, differ also in their use and potentialities. For this reason it has become necessary to classify these various kinds of soils so that they can be grouped accordingly and their study, both scientific and practical, be conveniently done.

Soil classification is comparatively a very recent field of study in soil science. Different countries have different methods of classification. The method followed in this survey is patterned after that of the United States. This method consists of the study of the individual characteristics of the soil and not on the factors that affect or produce them.

The soils in the province of Palawan may be classified for convenience into lowland and upland. The percentage area of the former is, however, very insignificant compared to the latter.

Each soil type is described in this report. Their respective areas, comparative sizes and their present uses are shown in table 10 and their distribution is shown in the soil map which accompanies this report.

The soils of the lowlands are usually alluvial soils, that is formed through water deposition. Alluvial soils have a flat or level topography with generally poor internal drainage. Upland soils are usually those that were formed in place from the underlying bedrocks or residual in nature. Upland soils generally have rolling topography with excessive external drainage and mostly eroded as in the case of cultivated areas. The miscellaneous land types are the swamps and marshes and beach sands which do not have developed profiles. It also includes most non-agricultural lands such as steep mountains.

The soils of the province are classified as follows:

I. Soils of the plains	Soil type No.
1. Bay clay loam	23
2. San Manuel clay loam	236
3. Aborlan loam	608
4. Busuanga loam	695
5. Babuyan clay	694
6. Babuyan silty clay loam	654
7. Brooke's clay	604
8. Brooke's clay loam	605
9. Quingua clay loam	109

II. Soils of the uplands	
A. Calcareous soils	
1. Bolinao clay	153
2. Sibul clay	14
3. Faraon sandy clay	702
B. Non-calcareous soils	
1. Coron clay loam	681
2. Tapul clay loam	459
3. Tagburos clay	693
4. Malalag clay	716
5. Guimbalaon clay	205
III. Miscellaneous land types	
1. Hydrosol	1
2. Beach sand	118
3. Rough mountainous land	202

TABLE 10.—*Soil types, their areas and present uses in Palawan Province*[1]

Soil type Number	Soil Type	Area in Hectares	Per cent	Present use and/or vegetation
1	Hydrosol	39,000	2.64	Nipa, bakauan, and other halophytic plants
14	Sibul clay	87,000	5.90	Upland rice, coconut; primary forest
23	Bay clay loam	2,900	0.20	Lowland rice, vegetables
109	Quingua clay loam	8,200	0.56	Upland rice, corn, tobacco; primary and secondary forest
118	Beach sand	14,500	0.98	Coconut, source of silica sand for glass manufacture
153	Bolinao clay	10,000	0.68	Upland rice, corn, coconut, banana
202	Rough mountainous land	785,750	53.29	Primary and secondary forest; sika (variety of rattan)
205	Guimbalaon clay	4,800	0.33	Coconut, upland rice, mungo, cassava, cashew; binayuyo, cogon, and shrubs
236	San Manuel clay loam	27,250	1.85	Coconut, banana, upland rice, corn
716	Malalag clay	6,750	0.46	Secondary forest
459	Tapul clay loam	47,000	3.19	Upland rice; primary forest, bohó, sika
604	Brooke's clay	27,000	1.83	Upland rice; cogon and binayuyo trees
605	Brooke's clay loam	24,000	1.63	Coconut, upland rice; cogon and binayuyo trees
608	Aborlan loam	8,800	0.60	Small, sparsely grown grass with short, hard pointed leaves
654	Babuyan silty clay loam	9,800	0.67	Coconut, upland rice, corn; secondary forest
681	Coron clay loam	182,500	12.38	Upland rice, cashew trees, jackfruit, mango; grassland, primary and secondary forest
693	Tagburos clay	68,500	4.64	Upland rice, corn, cassava, sweet potato
694	Babuyan clay	3,750	0.25	Primary and secondary forest; cogon
695	Busuanga loam	6,650	0.44	Lowland and upland rice, cassava, sweet potato
702	Faraon sandy clay	27,000	1.83	Corn, citrus, upland rice, coconut; primary and secondary forest
	Unsurveyed[2]	83,420	5.65	
		1,474,570	100.00	

[1] Area of different soil types obtained by planimeter. No deductions were made for bodies of water.

[2] Islets and other outlying islands of Palawan Province were unsurveyed due to lack of transportation facilities.

SOILS OF THE PLAINS

BAY SERIES

Bay soil was first identified in the province of Rizal in an area close to Laguna Lake. It is characterized by a topography which is practically level and low. Being close to bodies of water, the water table is shallow, and generally external drainage is poor. Original vegetation has been completely removed as the land has been cleared for lowland rice.

Soils of this series are alluvial deposit. The surface soil is clay to clay loam, dark gray to grayish brown. The subsoil is also clay but of medium olive gray color. The substratum is also of the same color but usually transcend to silty clay or even sandy clay at the lower depths. The pale color of the subsoil and substratum may be due to poor drainage.

Bay soil has profile characteristics as follows:

Depth (cm.)	Characteristics
0– 20	Surface soil, dark brown clay loam to clay. Fine granular and friable when dry but sticky when wet. It is free from rock outcrops or coarse skeleton; fair in organic matter content.
20– 60	Subsoil, bluish green to olive gray sticky clay; soft when wet; free from stones or pebbles; organic matter content is poor. The boundary to the overlying layer is smooth and diffused.
60–150	Silty clay, bluish green to olive gray. Plastic when wet and slightly gritty to touch. No stones or pebbles present. The boundary to the overlying layer is smooth and diffused.

Bay clay loam (23).—This soil type is found within the compound of the Iwahig Penal Colony. It comprises the low and flat areas which are at present devoted to lowland rice. This area is of recent alluvial deposit covering a former swamp.

Being low and lying close to the hydrosol area, the water table is only 60 centimeters from the surface. Surface drainage will most likely be very poor especially during times of heavy precipitations. For this reason lowland rice is grown during the rainy season. During the dry season when the soil is fairly dry vegetables can be planted.

The surface soil of this soil type is clay to clay loam and ranges in depth from 15 to 25 centimeters. It is pale brown to light brownish gray and is very hard when dry. When wet the soil is soft but rather sticky and plastic and becomes darker in color. Its organic matter content is fair and is

partly maintained by the decomposition of rice straws left in the field and by the decaying root system.

The surface soil has a neutral to slightly acidic reaction, or roughly a pH 6.5 to 7. Rice is a crop which requires a fairly acidic soil or that whose pH is from 5.5 to 6.1. Under this condition it is apparent that an addition of fertilizer with an acidic residual effect is necessary.

The subsoil is also clayey and is usually moist unlike the surface layer. The color, however, is a strong departure from that of the surface, being pale gray to olive gray. It is plastic but only slightly sticky. This layer extends to 60 centimeters deep from the surface. It is also to this depth where the water table stands. The depth of the water table varies, however, being shallower near the edge of the hydrosol and deeper at the edge of the hinterland.

The substratum has the same color as that of the subsoil slightly differing only in texture and consistency. While the subsoil is clay, the substratum grades gradually downward from clay to silty clay. The consistency of the layer naturally varies with the texture, that is from plastic to slightly plastic and mellow at the lower depths.

Bay clay in Iwahig is used for lowland rice. With irrigation, *Apostol* rice variety planted on this soil type yields about 40 cavans of rice per hectare. This crop is planted from June to July and harvested about November. The field is seldom used after the rice harvest. Sometimes vegetables like gourds are planted and yield quite well.

SAN MANUEL SERIES

This is one of the important alluvial soils found in many regions in the Philippines. It is highly suited for agricultural purposes, not only because of its relative fertility but because this series is flat, and drained by many creeks and rivers.

The surface soil is so friable and loose that tillage operation is easy, and root penetration reaches to great depths. The soil is usually of the silt loam class although at times clay, clay loam, and sandy loam are present. The subsoil likewise is loose ranging from silt loam to fine sandy loam. The lower layers are also similar to the subsoil in consistency and class although coarser texture may also exist. Characteristics of this profile are uniform brown color of the soil in the different

layers and the absence of any coarse skeleton in any of the soil horizons. The water table is usually from two to four meters from the surface.

San Manuel series has profile characteristics as follows:

Depth (cm.)	Characteristics
0– 30	Surface soil, grayish brown to pale brown clay loam to loam, friable and coarse granular. When wet it is soft and friable. No coarse skeleton present. Fairly rich in organic matter.
30– 90	Subsoil, brownish gray to pale brown silt loam with yellowish brown streaks, mottled yellowish brown. It is friable and fine granular in structure, non-calcareous. No stones or pebbles present in this layer.
90–150	Substratum, yellowish brown to light brown, fine sandy loam with no stones or pebbles. This layer extends to two meters or more in depth.

San Manuel clay loam (236).—This soil type is found on the coastal plains of Aborlan, Panacan, and Tarusan, all along the eastern coast of Palawan.

These alluvial plains are well drained as they are traversed by many creeks and rivers. Some of these rivers have their headwaters in the upland regions and the other originate right on the plains. The rivers swell during heavy downpour and some become dry during the dry season. Their use, therefore, for irrigation purposes should first be studied. Another characteristic of this soil is the absence of stones or other rock outcrops. Coupled with its loose or friable consistency tillage of this series is easy and convenient.

The surface soil ranges from 25 to 40 centimeters deep, clay loam to loam and sandy loam. The coarse granular structure and friable constitution contribute much to the desirability of this soil for farming. The subsoil is silt loam ranging in depth from 50 to 90 centimeters from the surface and is usually pale brown to yellowish brown in color. Like the surface layer the subsoil is loose and friable. Being a result of deposition, this soil is deep and extend to over two meters from the surface before the unconsolidated sandy material is reached. The substratum represents a soil of homogenous color which is yellowish brown to light brown. The texture is coarser than that of the solum as ordinarily it is fine sand or even sandy loam.

While its agricultural importance is very apparent, soils of the San Manuel series are rather limited in extent. This soil type has a total of 27,250 hectares which is only 1.85 per cent of the area of Palawan Province. In Aborlan where this soil is found, it is mostly used for planting fruit trees. Coconut seems to be the only important farm crop grown. Upland rice and corn are also planted as in some areas in Babuyan. Rice and corn, however, do not seem to be the main crops as most of the farms are newly opened and the land has not yet been plowed.

Some areas within this type occur as San Manuel silt loam and San Manuel sandy loam in the Aborlan, Agricultural School site and used for the planting of bananas and coconuts.

In Panacan area both the loamy sand and sandy loam texture occur which are too small to be delineated. These soils are used for coconut. Being near the sea, good stands of coconuts are produced.

This soil has a neutral reaction and as such many kinds of legumes like mungo, cowpeas, soybeans, and beans can be favorably grown. Furthermore, the planting of any kind of legume on this soil should be encouraged and included in the rotation of crops so as to maintain its fertility. Rice, on the other hand, favors a soil which is moderately acidic or one which is between a pH 4.8 and 6.9.

ABORLAN SERIES

The wide level area near Aborlan, wherein the vegetation is nothing more than small and sparsely grown grass, was classified under this series. The relief is partly broken by the numerous creeks that traverse this area. Gullies, developed as a result of erosion, have somehow altered an otherwise level land. Being flat, drainage is expected to be poor. Internal drainage is very slow owing to the compact layers below the surface causing water to flow off the surface after a heavy rainfall. This runoff contributes much to the formation of gullies. Almost all of the creeks and rivers in the locality are intermittent.

The present vegetation on this series is very striking in contrast with those of other plains. On such a very wide plain, nothing seems to be noticeable except small grasses with short,

hard and almost sharply pointed leaves. The grasses grow very sparsely which somehow also attribute to soil erosion. Cogon or *talahib* is absent except along borders of other soil series. Usually, *binayuyo* trees are associated with grasslands. This tree is not found in this locality. The banks of creeks and rivers that traverse this area are lined with second growth trees consisting of several species of small trees with characteristics similar to those of "parangs."

The soil also possesses a very striking appearance not common to other known series. The surface soil is shallow, has a very light gray color and friable. The subsoil and substratum, however, are dark brown or yellowish brown to strong brown and are very compact. Generally there are no gravels or stones found in the lower layers. Boulders in the substratum are absent. An important characteristic of the surface soil is its high acidity. Very few plants have tolerance for soil with an average of pH 5 and this condition may also attribute to its relative unproductiveness.

In external characteristics, Aborlan series may appear similar to those of Silay series. Both have surface soils of the same color as well as reaction. Drainage conditions for both are also identical. However, the compact substratum of Silay is white to gray whereas that of Aborlan is dark brown.

Aborlan series has a profile with the following characteristics:

Depth (cm.)	Characteristics
0– 25	Surface soil, loam, pale brown to light gray when dry, dark gray when wet; good fine granular; slightly compact when dry but friable when wet; very poor in organic matter; non-calcareous; no coarse skeleton; and a pH of 6.
25– 55	Subsoil, loam, light yellowish brown when dry, becomes slightly darker when wet; hard and very compact when either dry or wet; poor in organic matter; no coarse skeleton; non-calcareous; and a pH of 6.
55–150	Substratum, clay loam, strong brown to moderate reddish brown; slightly compact and hard; massive; no coarse skeleton; non-calcareous; and a pH of 5.

Aborlan loam (608)— This is the only soil type under this series. It is found in the municipality of Aborlan. This land is ideal for agricultural purposes it being almost level to very slightly undulating. Machinery can be used to a big advantage

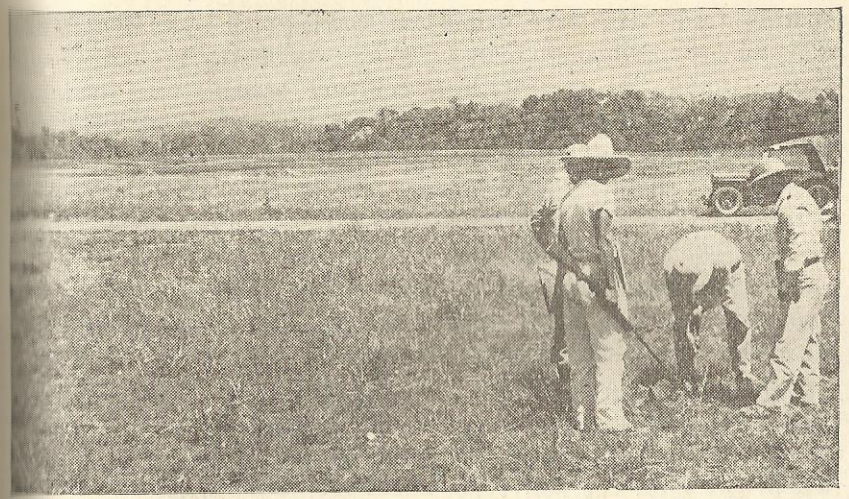

Fig. 21. The landscape near Inagawan before the town of Aborlan. The land is level but only a species of grass called *quirib* grows on it. Soil is acidic, low in organic matter and very low in phosphorus.

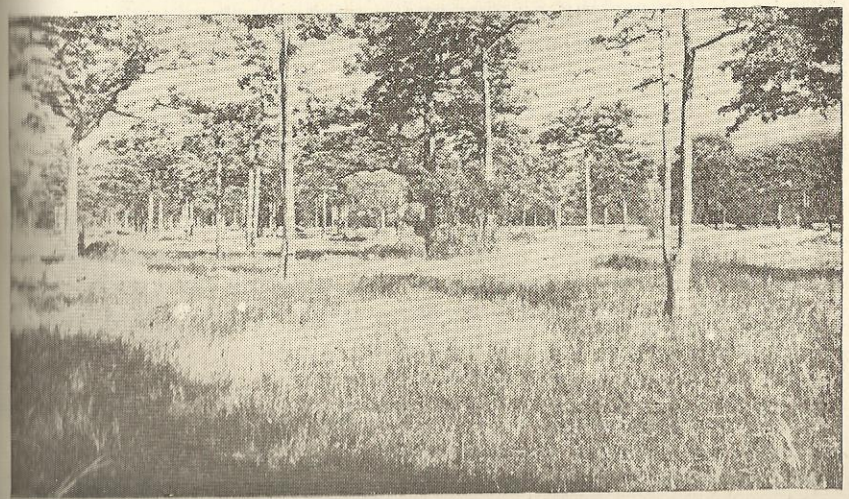

Fig. 22. The eastern side of Palawan has more level areas than the western coast. This unoccupied plain in Brooke's Point is covered mostly by cogon and *bangkal*. The clay soil is hard and sticky.

PLATE 8

in this area. However, for some factors still unknown in the soil, no economic plant can be grown to maturity in this soil type. Being flat and with a compact substratum, drainage becomes a factor to be seriously considered. Uncontrolled surface runoff has ruined many areas in this soil type. The numerous creeks and rivers that cross the area draw all the water to the sea. Most of these creeks become dry during the summer months, hence a problem to irrigate the area.

Aborlan loam must have been probably farmed under the *kaingin* system so many years back and then abandoned after substantial production could no longer be obtained.

During the survey, this soil type was not planted to any crop nor were there any people living on it. It is an abandoned area. Cattle and carabao seemed to avoid the coarse grass which grew on the soil type.

This soil is low in fertility and at the same time very acidic. Its reclamation can be done by correcting such deficiencies. The problem of acidity should first be solved by proper liming. Once this is corrected legumes may probably have a start, or if not, the soil should be inoculated and fertilized with phosphorus to grow leguminous crop that will make a green manure. This is in line with correcting organic matter deficiency of this soil. Correcting acidity and restoring organic matter will probably make this soil type again fitted for farming.

BUSUANGA SERIES

This soil was first identified in the island of Busuanga. It occurs as new valley with surrounding low hills from where the soil originated. The land is level like those of San Manuel or Babuyan soils. The drainage is poor. Busuanga soil is brown to light brown whereas Babuyan soil is light gray.

The typical profile characteristics of the series as represented by Busuanga loam are as follows:

Depth (cm.)	Characteristics
0– 20	Surface soil, loam, silt loam to clay loam; grayish brown to almost black and dark gray; fairly friable and slightly compact with fine granular structure in undisturbed areas; in some instances, gravels may be found.
20– 50	Subsoil, loam to clay loam; dark brown to grayish brown; fairly friable; fine granular structure. Boundary with overlying layer is smooth and diffused.
50–150	Substratum, gravelly clay loam to sandy clay; gray to light brown with brown mottlings; slightly compact; coarse granular structure.

Busuanga loam (695).—This soil type is found in many of the river valleys in the island of Busuanga such as in Concepcion and Calawit. It is also found in the Negative Barrio in Culion and in a stretch of land between Taytay and Bato. The land is nearly level. The middle part of the valley has poor drainage while the adjoining uplands are fairly well drained.

The soil is mostly used for the culture of paddy rice. In Salvacion, farmers plant the local variety called *Cabunglok*, which yields about 20 to 30 cavans of palay per hectare. *Elon-elon* variety yields 25 cavans of palay per hectare. Upland culture of rice is also done and the variety *Pindinga* yields about 25 cavans of palay per hectare. Other crops grown are cassava and sweet potatoes.

The soil is slightly acidic to almost neutral. It is very deficient in lime. The organic matter content is likewise low. Better crops can be expected from this soil type if proper liming and green manuring are practiced. The fertility is also low and fertilization following the recommended kind and quantity should be observed.

BABUYAN SERIES

Soils of the Babuyan series are found fringing the narrow coastal plains on the eastern and western sides of northern Palawan. The series has similar characteristics to those of the San Manuel series. The land has a level relief. Unlike San Manuel series, however, Babuyan series has poor internal drainage with light gray to gray soils.

The typical profile characteristics of the series are as follows:

Depth (cm.)	Characteristics
0– 15	Surface soil, silt loam to clay; light yellowish gray to light gray with red mottlings; slightly compact; coarse blocky structure.
15– 60	Subsoil, light gray to light yellowish brown clay, coarse, blocky structure; slightly compact when wet, becomes hard on drying. Boundary with surface soil is smooth and diffused.
60–150	Substratum, light gray clay with brown mottlings; structureless; soft when wet, hard and compact when dry.

Babuyan clay (694).—This soil type is found in Danlig, a large area in Malcampo, and in a smaller area in Aboabo. The soil has a very light color which is suggestive of low organic matter content. All the places where this soil is found are traversed by rivers. These rivers overflow their banks and cause floods. The river in Malcampo is quite destructive as its waters often rise from one to two meters above its normal level. If the land is to be farmed, it should be done at the time of the year when rainfall is lowest. September to December receives the most rain during the year.

This soil is potentially low in fertility and very likely heavy fertilization is necessary. Tobacco will thrive well on this soil if this plant can be grown during periods when floods do not occur in the area.

The soil needs plenty of organic matter which can be supplied only through green manuring. Rice and corn can also be grown but they should be fertilized well. At the time of the survey, the area in Malcampo is still under virgin forest. Those in Danlig are cogonal and those in Aboabo are under secondary forest.

In the Aborlan Agricultural School site, this series occurs as Babuyan sandy loam and silt loam. The surface soil is friable but the deeper layers have poor permeability. For this reason, the fields where these soil types are found are planted to rice.

Babuyan silty clay loam (654).—This soil type is found in Babuyan on a narrow coastal plain on the eastern side of the island of Palawan. The soil formed is a product of water deposition originating from the upper hilly areas. It is also found in Aborlan, and in scattered places along the northeastern and northwestern coasts of the mainland. The soil type aggregates to 9,800 hectares.

The land is generally level but broken at frequent intervals by white ant mounds which sometimes reach to over a meter high. Drainage is slightly poor as spots of water-logged areas exist. The water table during the dry season is only a meter and a half from the surface which certainly attains a much higher level during the rainy days. Areas bordered by hydrosols have even poorer drainage conditions.

The vegetation consists of only second growth trees which show that the primary forest had long been cut. The present

FIG. 23. This is a plain in Panacan recently cleared for cultivation. Holes are made in the ground into which women drop few seeds of upland rice. The soil is San Manuel loam.

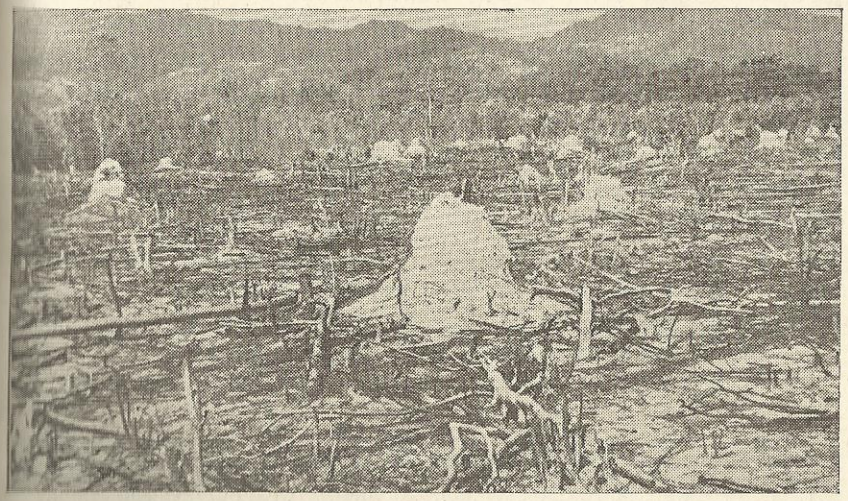

FIG. 24. This is a landscape of Babuyan silt loam, level and fairly productive. Lower layer of soil is clay loam which is grayish white and poor in minerals and organic matter. Note the mounds on the clearing.

PLATE 9

plantings are on cleared second growth forests which consist mostly of *binunga*.

The surface soil, with a depth of from 20 to 25 centimeters, is brown to light brown and at times gray for those areas that had been under long cultivation. The soil is fine granular to even structureless, very friable and loose. Such soil is very easy to till and affords good penetration of roots to the lower layers. The subsoil is likewise loose, friable and deep with no physical obstruction of stones or boulders like other soils in the province.

Generally, the soil is productive, it being only recently opened to cultivation, but such fertility may not be for long. Continuous planting to corn and rice will soon render any fertile soil unproductive unless conservation measures are adopted. Crop rotation wherein legumes are included is essential in any fertility maintenance program.

At present coconut is the main crop planted in this soil. The trees are healthy and productive, usually yielding up to 60 nuts a tree a year.

BROOKE'S SERIES

This soil occupies the narrow coastal plain in Panacan and Brooke's Point both in the southern part of the mainland. The land is almost level to very slightly undulating. The nature of the fine textured soils in the profile makes internal drainage very poor. There are no rocks either as outcrops or in the lower layers of the profile. In Panacan, instances of former river beds traverse the area as marked by numerous gravels and stones. These old river beds were later covered by soil during the early period of land formation.

The typical profile characteristics of the series are as follows:

Depth (cm.)	Characteristics
0– 20	Surface soil, clay to clay loam; light brown when dry, dark gray to almost black when wet; coarse granular to blocky; soft when wet, hard when dry; fair in organic matter; no rock or other coarse skeleton.
20– 70	Subsoil, clay, light brown to yellowish brown; coarse granular to massive structure; hard and compact when dry, soft when wet; no coarse skeleton. Boundary with surface soil is smooth and diffused.
70–150	Substratum, clay, light brown; compact and hard when dry, sticky and plastic when wet; no coarse skeleton. Boundary with subsoil is also smooth and diffused.

Brooke's clay (604).—This soil type is found covering a big area in Panacan and northern part of Brooke's Point. The land is almost level and both external and internal drainage is very poor. Trees like *bangkal* abound in the area. The land had been cleared before and probably *kaingined* and now covered by cogon. The soil is fairly rich in organic matter content as evidenced by the black color of the soil and the presence of numerous small mounds of soil excretion of earthworms as well as mounds of termites. The soil is heavy clay and for upland culture of crops the proper moisture content of the soil should be studied beforehand in order to attain good granulation. This soil is better used, however, for lowland rice culture.

The soil has a pH 6.6 which is good for many kinds of crops. This reaction is not favorable for lowland rice but if ammonium sulfate fertilizer which is really needed, is applied the pH value may go down. The soil, however, is very poor in calcium and if agricultural lime be added the reaction may go towards the alkaline side which is not favorable for rice.

The upland rice planted here are *Sipango* and *Binirao* which produce from 39 to 60 cavans of palay per hectare. The high yield is attributed to the relatively newly opened land. The nature and origin of this soil show that its fertility is easily depleted and that the yield of the succeeding crop may drop considerably if not fertilized.

Brooke's clay loam (605).—This soil type is found adjoining the other type in Brooke's Point. The soil type is very similar to Brooke's clay, differing only in the texture of the surface soil. The native vegetation consists of *aper* or *parang* type of forest with cogon grasses and *binayuyo* trees. The cultivated areas are planted to coconut and upland rice. Coconuts yield from 80 to 120 nuts per tree a year. The upland rice variety planted is locally called *Pindinga* which is a high yielder, oftentimes production reaching to 60 cavans of palay per hectare. This yield, however, is true only in newly opened lands.

QUINGUA SERIES

This soil series is found in the northern part of Panacan and is similar to the San Manuel series. The former differs from the latter only in the color of the soils in their profiles. The series is also of alluvial deposition with an almost flat topography. It is well drained by many creeks and rivers.

Malatgao River is the biggest among them. There are no stones or other rock outcrops.

The greater portion of this soil is already cleared by squatters as there is yet no land subdivision. Some parts of the virgin areas are still covered by non-commercial and commercial forests. *Ipil* and *apitong* are abundant in this place.

Quingua silt loam has profile characteristics as follows:

Depth (cm.)	Characteristics
0– 40	Surface soil, silt loam to clay loam; light brown, yellowish brown to brown; color varies with amount of organic matter content; loose and structureless. No rock outcrops.
40–100	Subsoil, silty clay loam; dark brown, light brown to reddish brown. Texture of this layer is heavier than that of the surface soil. In some places the subsoil is friable and loose, but on the average it is compact.
100–150	Substratum, silt loam to silty clay loam; brown, brownish yellow to reddish brown; loose, slightly friable and compact.

Quingua clay loam (109).—This soil type is a fairly fertile soil that is friable for upland rice, corn, and tobacco. The soil is friable and fairly rich in organic matter. The surface soil is slightly acidic in reaction. It is low in phosphorus and calcium. Ammophos fertilizer will help much to increase its fertility. Agricultural lime should be added before preparing the land for planting. Some of the southern shores of Palawan contain calcareous beach sand which can be used for agricultural purposes. Green manuring, to increase the organic matter content of the soil, is essential and may help minimize the amount of needed commercial fertilizer. This soil is productive when thoroughly prepared.

The coarser texture of Quingua like sandy loam, loam and silt loam are also found within the soil type.

Soils of the Uplands

CALCAREOUS SOILS

Soils under this category are primary or soils developed in place from limestone rock. There are three soil series, namely, Faraon, Sibul, and Bolinao. These aforementioned series differ from each other in soil color and in the nature of the limestone rock from which each originated. Limestone is found in many places in the province. In the northern part of the mainland such as in Bacuit and Taytay, the rough mountainous areas especially in the caves where edible bird's nests are found, are of limestone formation. Several small islands in that area are also of limestone. Coron Island in the Calamianes Group presents a spectacular sight of protruding limestone needles. The mountains underneath which the underground river flows before emptying into St. Paul Bay are also of limestone. Underground rivers, caves, and springs are natural occurrences in areas of limestone formation.

BOLINAO SERIES

The most important and distinct characteristic of this series is its dark brown to red soil developed from coralline but porous limestone. The soil developed is shallow and is immediately underlain by the limestone rocks. This series has a rolling to hilly relief and possesses good internal drainage.

Bolinao clay (153).—This soil type is found near the town of Puerto Princesa and in Rio Tuba in the southern part of the mainland. The land is gently undulating to rolling. The surface soil ranges from 10 to 15 centimeters deep and consists of reddish brown to dark red clay. It is plastic and sticky when wet, friable when almost dry. Unlike other clay soils, Bolinao clay does not crack or puddle even when plowed wet. The surface soil contains some stones or pebbles of limerocks. At times the bedrock appears as outcrops in which case plowing is difficult.

The subsoil may at times be absent, but in deep soils, evidence of this layer may show. Bolinao clay is suitable for corn, coconut, citrus, bananas, and legumes. Lowland rice is not adaptable. Upland rice like *Pindinga* may yield from one to three cavans of palay for every ganta of seed or about 30 cavans of palay per hectare.

SIBUL SERIES

Sibul is another calcareous soil also formed from limestone. One difference, however, of this series from the Bolinao or Faraon series is the massive nature of the limerock. The clay soil is black and plastic. It becomes compact on drying. The relief is hilly and external drainage is excessive.

Sibul clay (14).—This soil type is found near Alfonso XIII covering the hilly areas on the western part of Palawan. At present this type is covered by thick forest. *Kaingins* are also found in patches all over the area. The surface soil is a waxy black clay that is plastic and sticky when wet. Out-

crops of limestone rock are strewn all over the area. This rock makes cultivation by plow and harrow impossible. Cultivated areas were very limited during the survey. Coconut is the only crop observed devoted to this soil type. This crop occupies a great portion of the western hills close to the shore. A large coconut plantation is located in this area. The main problem of the plantation owner is the presence of wild pigs. Citrus may also be planted on this soil type. The open land under grass is suitable for pasture.

FARAON SERIES

Soils of this series are calcareous but unlike those of the Bolinao and Sibul series, the soil of Faraon is black and fairly friable and the bedrock is porous coralline limestone. The soil has a good drainage. The relief is rolling to hilly. This soil is found mostly in the southern part of Palawan. Like other limestone soils, Faraon series is marked by the presence of numerous outcrops.

Faraon sandy clay (702).—This soil type is found in the island of Bugsuk and in the northern part of Balabac. The land is rolling. The soil in Bugsuk is light brown to pale brown and is fairly deep. It is mostly covered by forest where *ipil, calantas, marango,* and *akle* abound. Only in this forest of the country is the rare mouse deer found. The cultivated areas are grown to corn and citrus both of which thrive well. Upland rice of the *Pindinga* variety is also grown yielding about 2 cavans of palay for every ganta of seed, approximately 20 to 30 cavans of palay per hectare. It was observed that few coconuts are grown on Faraon sandy clay in the province, a crop which will do well on this soil type.

NON-CALCAREOUS SOILS

The soils developed from rocks other than limestones were classed under this group. The rocks are mostly igneous, like andesite, basalt and quartz. Tagburos, Malalag, Tapul, and Guimbalaon soils originated from these rocks. Other parent materials include metamorphic rocks like cherts and gneiss which produce soils like those of the Coron series. All of these soil series have rolling to hilly relief. Tapul and Guimbalaon have fairly deep soils and with thick vegetative cover while the others have shallow or poor soils that produce many of the very hard woods.

CORON SERIES

The hilly and mountainous areas common in Culion and Busuanga Islands were classified under the Coron series. The northern part of Bacuit in the mainland of Palawan also belongs to this soil series.

Soils of this series are not very suitable for agricultural purposes because their topography is oftentimes hilly with steep slopes. Small valleys are found and they can be cultivated. Some valleys with wide areas, however, cannot also be cultivated as they are littered with pebbles and gravels—the result of severe erosion from the upland.

A large part of this area is an open grassland with scatterings of small trees. There is less cogon or *talahib* but more often dominated by another species of grass locally called *garas* or *paray-paray*. The presence of this grass suggests that the soil in this area is often dry. The trees growing are the *palo de hierro* or iron tree, some *binayuyo*, and cashew. The latter grow wild in almost all areas in the province. *Palo de hierro*, as the name suggests, is a small tree with a very hard wood. Hard woods are usually found in places with shallow, very poor and rocky soils and a dry climate.

Virgin forests are also found in the more or less inaccessible areas. The forest growth is very sparse with comparatively low trees. One important wood in this forest is the *dulo* or *urung* which is similar to the molave. It is often used for posts of houses. Other species are *akle*, molave, white narra, and *yakal*.

Coron series has soil that is gray to brown. The soil layer is shallow and in the open areas soil erosion is very severe so that practically the surface soil and the subsoil are gone. As a result, the bedrock is exposed or fragments of rocks litter the ground surface. The bedrock is mostly of chert, jasper, or shale. These rocks are rich in quartz and are used for road surfacing. The subsoil is dark brown clay to clay loam while the substratum is of the same texture although harder and more compact than the subsoil. In this layer rock fragments are present. Below this layer are the laminated chert rocks in various degrees of faulting or strikes. These rocks are usually associated with manganese ores.

Drainage is good to very excessive. External drainage is very excessive which contributes much to soil erosion. Inter-

nal drainage, on the other hand, is slow. Very little moisture is stored thus the condition of comparative dryness often exists.

Profile characteristics of Coron series are very variable that at times it may be considered a soil complex. In spite of the uniformity of its surface features no uniform profile exist within the series. The profile characteristics of Coron series have no apparent similarity with any other soil series already identified. Rock fragments and erosion pavements of chert make this series unique. A characteristic profile of this series is as follows:

Depth (cm.)	Characteristics
0– 10	Surface soil, clay loam; gray to light brown; coarse granular; slightly friable when wet, slightly compact when dry; poor in organic matter; at times pebbles and gravels are present. Soil is non-calcareous.
10– 40	Subsoil, clay to clay loam; dark brown to light reddish brown; compact to slightly hard when dry, moderately plastic when wet; and, with a coarse granular structure.
40– 60	Fragments of chert and jasper are present. Non-calcareous dark brown clay, mixed with fragments of rocks. Hard when dry but plastic when wet.
60–150	Partly weathered to unweathered rocks of chert and jasper. Rocks are dark brown to reddish brown, laminated and usually faulting upward following slopes of the hills. In other places, this layer is found much deeper and in this case the profile is similar to that of Tapul or Tagburos series.

Coron clay loam (681).—This is the only soil type under the series and is found covering the upland areas in Culion, Busuanga, and northern end of Bacuit. Some of the adjacent islands in the places mentioned are also of the same soil type. The hilly areas vary in elevation from 200 to 1,000 feet above sea level. Some portions of the slopes of these hills have good soil and can be cultivated but the rest of the upper portions are highly eroded and unfit for cultivation. In Culion the slopes range from 20 to 35 per cent whereas in extreme cases as in Busuanga Island slopes are 35 to 60 per cent.

Coron clay loam is well drained. External drainage is so fast or excessive that very little infiltration takes place after a rain. For this reason there are no big rivers and most of those which exist dry up during the dry season.

The surface soil is from 10 to 20 centimeters deep. Deep layers are found in undisturbed flat or gently sloping areas. The greater part of the area, however, is already under open grasslands, the result of previous *kaingins*. In such cases, most of the surface soil is eroded or totally washed away leaving only the bare bedrock. In eroded areas, the surface of the ground is strewn with numerous rock fragments or erosion pavements exist which further make the cultivation of this soil type difficult. This soil, in the first place, should not be planted to annual crops because clean culture cultivation induces soil erosion. Recently planted upland rice were noted in newly opened virgin forest. No attempts are ever made to farm in open grasslands which were once *kaingin* sites.

Rice is the principal upland crop. The *Kamoros* variety, which is another name for *Pindinga,* is commonly used. This kind of rice variety yields about one cavan of palay for every ganta of seed. This rate is much lower than those in the mainland of Palawan. This low yield is possibly due to poor soil and lack of sufficient soil moisture.

To make this soil type useful it should be reforested. In places where the slopes are not very steep permanent crops like fruit trees should be grown. It was noted that cashew thrives very well on this soil. The cashew tree is tolerant to dry conditions and can also thrive even on poor soil. Jackfruit and mango were also noted to grow well. Commercial scale planting of these trees can be done on this soil type.

TAPUL SERIES

This series is found in the hilly areas in the central portion of Palawan. The slopes are not steep and can be cultivated with a certain degree of precaution against soil erosion. Boulders or stones as outcrops are not found in this series. With slopes from 5 to 20 per cent, external drainage is quite facilitated. Internal drainage is fair. Drainage is good in areas under thick vegetative cover.

Vegetation consists of a thick growth or virgin forest with big timbers of commercial importance. The undercover is filled with entangling vines of many species of which rattan is the most important. Bamboos, chiefly *bohos,* cover wide areas on the secondary growths or abandoned *kaingins.*

Tapul soil is one of the best kinds of upland soils in the province. It is deep with reddish or dark reddish brown sur-

face and subsoil and a gray substratum. This soil is easily distinguished by the color of the solum and the substratum. Unlike that of the Luisiana series which is also deep, this series has a dark reddish soil which gradually fade out into gray with red mottlings. Soil horizons in the Luisiana series are very diffused and hardly distinguishable from each other. Tapul soil, however, has a more or less well distinguished soil horizons. Partly weathered dioritic rocks are still in evidence in the substratum of this series but which are absent in the Luisiana series. Tapul soil may also appear similar to Kidapawan series in Cotabato. In the Kidapawan series, however, basaltic rocks are present as outcrops. Furthermore, a layer of coarse gray sand is present in the substratum of the Kidapawan all of which are absent in the Tapul soils.

The morphological characteristics of Tapul soil are as follows:

Depth (cm.)	Characteristics
0– 35	Surface soil, clay to clay loam, dark brown to deep brown; good coarse granular structure; slightly sticky when wet, slightly hard when dry; rich in organic matter; non-calcareous, no rock outcrops.
35– 70	Subsoil, clay, reddish brown to brown; coarse granular to moderately columnar; hard and compact when dry, sticky when wet; fair in organic matter; non-calcareous and no coarse skeleton. Boundary with surface soil is irregular and gradual.
70–110	Dark brown clay; columnar to massive soil that is hard and compact when dry but sticky when wet; poor in organic matter; non-calcareous and with no coarse skeleton. The boundary with the subsoil is wavy and diffused.
110–150	Highly weathered rocks, light yellowish brown to light yellowish gray with little spots of black or dark gray. It is massive, hard and very compact. This material is weathered igneous rock most likely diorite. Boundary with upper layer is irregular and abrupt.

Tapul clay loam (459).—This soil type is found in the eastern part of Palawan north of Puerto Princesa. It covers the hilly forested and partly cultivated areas towards Babuyan. The forest, unlike other forest areas in Palawan, is thickly grown with big trees of many species such as *apitong, amugis, marango,* and *calantas.* These commercial timbers are usually cut for lumber. Several species of rattan are also found, the most important of which is the "sika" variety. This variety is mostly found on this soil type. The thick growth of vegetation can be attributed to the deep and fertile soil.

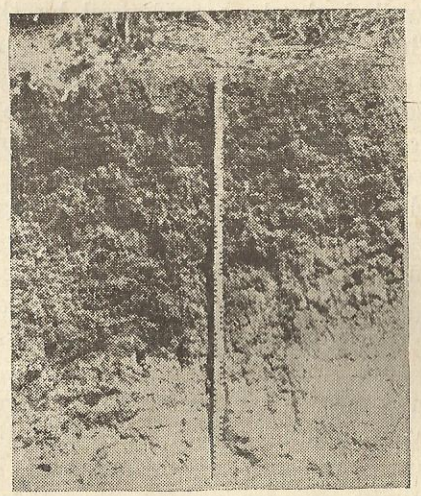

FIG. 25. A profile of Tapul series. Upper layers are brown to dark brown but the substratum is yellowish brown with evidence of partially weathered igneous rocks.

FIG. 26. A landscape of Tapul soil, hilly land covered by good stand of forest. Many clearings are made yearly for planting to crops.

PLATE 10

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The land is well drained as evidenced by the reddish color of the soil. The creeks and rivers do not run dry during summer. None of the rivers are navigable, however.

The surface soil, with a depth of from 20 to 50 centimeters, is clay to clay loam and range in color from dark brown as in the case of forest soil to grayish brown in open *kaingined* areas. Being clayey in texture, this soil is possibly difficult to work either wet or dry. The present predominating agricultural practice in most areas of Palawan, however, seldom employs plows and harrows to till the soil. The *kaingin* system of planting upland rice is generally done regardless of the physical condition of the soil.

Soil erosion has not so far shown any appreciable effect as comparatively very small portion of this soil type is under cultivation. Furthermore, a *kaingined* field is never re-cultivated. As a result, grasses, principally *bohos,* soon cover the field. In this way soil erosion is somehow checked or minimized.

The subsoil is also of fine texture and extends to almost a meter deep.

TAGBUROS SERIES

This soil series is found in Puerto Princesa and another larger area in the southern end of the mainland. It has a rolling to hilly relief and external drainage in the cleared areas is excessive. The internal drainage is slow. The soil was developed from igneous rocks mostly of basalts and andesites. Quartz are also abundant. The land is mostly forested with several areas under *kaingin* system of farming. The profile of this soil is as follows:

Depth (cm.)	Characteristics
0–25	Surface soil, clay to clay loam; dark brown; coarse granular structure; sticky and slightly plastic when wet, friable when dry; fair in organic matter.
25– 80	Subsoil, clay, dark brown to brown; coarse granular to blocky; also plastic and sticky when wet, slightly friable when dry. In this layer is a 30 centimeter layer composed of fragments of stones and gravels.
80–150	Substratum, clay, dark brown; sticky, hard and compact with a coarse granular structure. Some weathered rocks are present.

Tagburos clay (693).—This soil type is found around the capital and also another area at the southern end of Palawan.

The type is characterized by the rolling to hilly relief and the sticky clay soil. The soil is well drained. The thin vegetative cover does not afford ample protection to the soil against excessive runoff and as a result not too much water is stored. During the dry season most of the creeks traversing this soil type become dry.

Tagburos clay is fairly deep. It is brown to dark brown and fairly rich in organic matter. The soil has a very high content (61.20%) of colloid which makes it very sticky and difficult to cultivate. The subsoil is also clayey (55.60% clay) and has similar characteristics as the surface layer. The fine textured soils of the different layers of the profile accounts for the slow permeability of the series. During heavy rainfall, a very small amount of water percolates into the lower layers and there is too much runoff. Vegetative cover is very sparse so that the obvious result is excessive soil erosion.

The cultivated areas are grown to upland rice and corn. The stand of the crops is very poor. Other crops grown are cassava and sweet potatoes. Where areas are arable, the fertility of the soil should be built up first. This can be done by green manuring, adding organic fertilizer like guano and application of appropriate commercial fertilizer. Planting of crops should be in accordance with soil conservation practices so as to prevent or minimize soil erosion.

MALALAG SERIES

This series is found in the northern part of Puerto Princesa covering the hilly areas near the coast. This is a primary soil or soil developed in place from the underlying igneous bedrock. The shallow soil developed lies over a thick solid mass of rock. The vegetative cover is very thin and the trees appear like secondary growth. Actually, the soil is so low in fertility that very few plants are thriving. Whatever is growing is stunted, which makes the place look like a cut over area. No portion of this soil type was under cultivation at the time of the survey. The following is a typical profile characteristic of the series:

Depth (cm.)	Characteristics
0– 15	Surface soil, clay loam to clay, dark brown to reddish brown; blocky; sticky, highly colloidal clay; some stones present.
15– 40	Subsoil, clay, brown to dark brown; slightly compact; fine columnar structure; sticky and plastic. Some stones and even boulders are present.

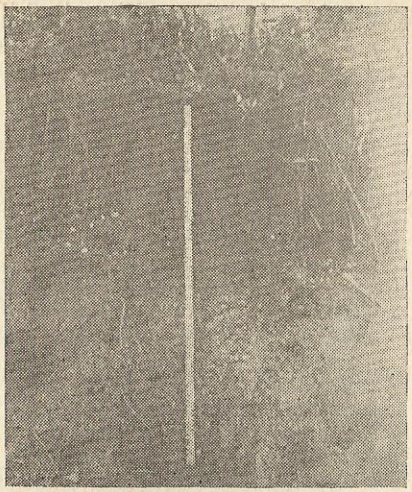

FIG. 27. A profile of Tagburos soil developed from igneous rocks. Upper solum is dark brown but substratum is dark gray. Rough and angular stones are present at 60 to 70 centimeters below the surface.

FIG. 28. A landscape of Tagburos series marked by its hilly terrain. Common vegetation are second-growth forest and bamboo groves. Several spots are cleared for *kaingin*.

PLATE 11

40–100 Weathered material consisting of angular fragments of igneous rocks, few slates, schists, and limestone.
100–150 Consolidated bedrock, light gray to gray, and very hard.

Malalag clay (716).—This soil type is found only in the northeastern part of Puerto Princesa. The hills in this area were classified under this soil type. The external drainage is excessive while internal drainage is poor. This condition promotes too much runoff and consequently soil erosion results. This soil type is not suitable for agriculture because it is shallow and rock outcrops are sometimes present. The soil exists in steep slopes which make its cultivation to row crops impractical. The best way to utilize this soil type is for tree farm or pasture.

GUIMBALAON SERIES

Soils of this series are primary soils developed in place from the underlying rocks which are mainly basalt and andesite. The decomposition of these igneous rocks gave rise to a red soil classified under a general group of latosols. This series is found only in Cuyo Island. The land is undulating to rolling. Internal and external drainage is good. Some characteristics of this soil are its acidic reaction, and it is low in available phosphorus and calcium. The availability of phosphorus in this soil is low because the element is tied up with the clay particles of the soil. It is fairly friable in spite of the clay texture.

Guimbalaon clay (205).—This soil type is found on the island of Cuyo. The land has an undulating to gently rolling relief and is well drained. Permeability of the soil is moderate to fast. Occasional outcrops of boulders are found. The surface soil is brown, light brown to even dark brown. The soil is clayey (48.80% clay) but in spite of such high percentage of the fine particles, the soil is fairly friable and well drained. The soil is deep often reaching depths down to 150 centimeters.

On the open lands called *parang*, several plants like *coramitas*, *binayuyo* trees, and cogon are common. The cultivated areas are grown to coconuts and upland rice. Rice yields from 10 to 12 cavans of palay for each ganta of seed are obtained. Mungo, cassava, and cashew are also planted. Cashew trees are either cultivated or wild. The soil needs liming and green manuring. Liming is necessary for the good growth of legumes.

FIG. 29. A cut in a hill in Tagburos showing the shallow soil of Malalag series. The thin stand of trees is an indication that poor soils are usually derived from metamorphic rocks.

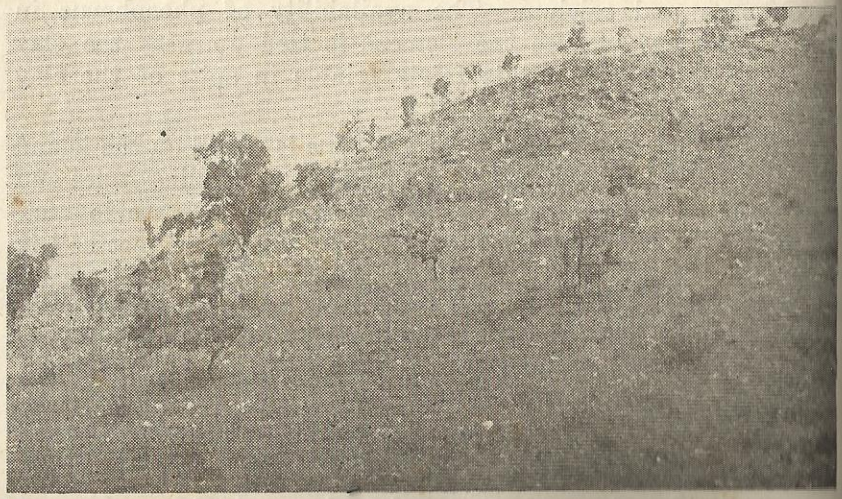

FIG. 30. A hillside in Culion Island showing the poor stand of vegetation. Iron trees dot the hillside, an indication of the poor and shallow soils of Coron series which are developed from chert, a very hard rock. Soil is stony.

PLATE 12

MISCELLANEOUS LAND TYPES

This general classification of land is not a true soil classification in the sense that the soils on these types of land are not well developed nor suitable for farming in general. These types include swamps and marshes or hydrosol, beach sand and rough mountainous lands.

Hydrosol (1).—The mangrove swamps along the coast of the mainland, like the shores bordering Taytay Bay; Danlig; Barbacan; Honda Bay, which is the biggest area in the province; Iwahig shores in Aboabo; and those along San Antonio Bay on the southern end of the mainland were classified under this type. There are few mangrove swamps on the western coast because mountains rise close to the sea. Several but rather small mangrove areas are found in Culion and Busuanga Islands. Most of the mangroves at the time of the survey were not developed. *Bakauan* trees stand almost 50 feet high. These trees and several other species of halophytes find ready markets. Firewood from these trees are cut and shipped to Manila for use in bakeries. Gathering firewood is a regular industry in the province especially at Coron.

Once the trees are removed from the swamps, the cleared area can be converted into fishponds. Fishponds should have clayey soil and not less than 30 centimeters deep. There should be a ready and regular supply of both fresh and sea water. These are special requirements for the growth of algae, the feed for the *bangos*. Another must in the industry is an adequate protection of ponds from floods or destructive waves.

Beach sand (118).—This land type represents an accumulation of soil materials which are mostly sand and sea shells carried by sea currents and deposited along the shore. As such, this form of land is subject to either erosion or washing away of the whole land or, on the other hand, an enlargement of an area as a result of continuous accumulation.

Beach sand is suitable for coconuts. The trees grown are more vigorous than those grown elsewhere. Vegetables will do well provided sufficient organic matter, like farm manure, is incorporated into the soil and adequate irrigation is provided. This soil drains rapidly and has a very poor water holding capacity.

The beach sand in del Pilar about 118 kilometers northeast of Puerto Princesa is shipped to Manila for the manufacture of

glass. The sand there analyzes about 98 per cent silica. There are two kinds of sand at del Pilar, light brown and the other almost white. Along Imuruan Bay on the western shore of the mainland is another extensive area of beach sand.

The beach sand on the southern shores of the province and on small islands like Ursula, Bugsuk, and Canabungan are also made up of silica sand and triturated marine shells. Analysis of beach sand from these localities indicate about 95 per cent calcium carbonate. The sand can be used for liming acidic soils or soils deficient in calcium. There are quite extensive deposits of this material in the places just mentioned.

Rough mountainous land (202).—The whole length of the central strip of the mainland of Palawan is dominantly mountainous and presently covered by forest. The formation of this mountain range is quite varied. In most parts of northern Palawan the rocks consist of chert, gneiss, and quartz. Since most of these are metamorphic and relatively hard rocks, weathering is slow and the soil produced is low in fertility as well as shallow. In consequence, the vegetation consists mostly of hard woods, very thin in stand with sparse understory. Some of the commercial forest trees are *apitong, guindaun, amuguis,* and *ipil.* In many forests of the Philippines *lauan* trees are found, but in Palawan trees of this kind do not grow. In areas where the soil is deep as on steep lands of the Tapul series, *calantas,* a soft wood for making cigar boxes, is found. In forests where the soil is clayey and moisture sufficient, *sika,* a variety of rattan very much in demand on the market, is found.

Culion and Busuanga Islands have rough mountainous lands. On these islands boulders of quartz are found all over the surface. The soil is well mixed with rock fragments. On this land type the rare and well known "iron tree" abounds. This tree is one of the hardest known woods. *Urung* is also found on these islands and is likewise known for its durability. These trees make good posts.

The soil formation along Saint Paul Bay is of limestone. Similar formation is found in Coron Island. On this island, practically no soil cover exist as the limestone rocks extend upward like columns of needles from the surface.

All these areas are not suited for farming and they are best left to forest stands. Most of these areas in the mainland are the headwaters of many rivers. Preserving the present forests will prevent floods and soil erosion.

CHEMICAL CHARACTERISTICS OF PALAWAN SOILS

MARTIN V. TIANGCO, GLORIA B. QUERIJERO AND EUSEBIO A. AFAGA[1]

A thorough knowledge of the characteristics of soils is the prime foundation in establishing a highly efficient and scientific agricultural practices. For this reason, the soils of Palawan were studied and classified according to their genetic and morphological characteristics found in the field, supplemented by the physical, chemical, and biological examinations of these soils in the laboratory. The results obtained from the laboratory investigations are useful in the planning of scientific and proper soil managements for increased crop productions.

The chemical analysis shows the following soil properties: (*a*) soil reaction or pH value which serves as a guidepost to crop adaptability of that soil; (*b*) concentrations of toxic substances; (*c*) available plant nutrients whether deficient, sufficient, or in excess; and (*d*) lime and fertilizer requirements of the soil type for better crop yields.

Carbon, hydrogen and oxygen come from air and water. The other elements are derived from the soil. Nitrogen, phosphorus and potassium are the primary nutrient elements and they are usually critical in soils as large quantities are removed by plants. They are the main constituents of complete mixed fertilizers. Calcium and magnesium in non-calcareous soils are inadequate, rendering these soils acidic and deficient in these two elements as food nutrients. Manganese, iron, boron, copper, aluminum, zinc and molybdenum are needed by plants in very minute quantities. Nevertheless, they are essential for plant growth and nutrition. These nutrients are called the trace elements. Absence or deficiency of any one or two of these trace elements in the soil produces negative results on the quality and quantity of crop yields. Relatively high concentrations of these nutrients, on the other hand, are toxic to plants.

Deficiencies of the nutrient elements from the soil are the effects of cropping, tillage, erosion and leaching. Nature cannot make up these enormous losses of nutrient elements as long as agricultural activities of man prevail. It is necessary, therefore, to apply organic and commercial fertilizers, composts, and manures to check such deficiencies. Trace elements sufficient

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for plant needs are incorporated in several brands of commercial mixed fertilizers.

METHODS OF CHEMICAL ANALYSIS

Rapid chemical tests for the readily soluble nutrient elements were preferred to the total analysis for two reasons: (*a*) Total determination are tedious, laborious and time consuming in extractions and in analytical procedures; (*b*) The response of plants to fertilizer applications correlates better with the results obtained from the rapid chemical tests than with those of the total analysis.

Under favorable soil reaction and temperature and in the presence of micro-organisms as nitrosomonas and nitrobacter, organic nitrogen is easily oxidized first to ammonia, then to nitrites and finally to nitrates. The nitrate form is readily available for plant assimilation. Total nitrogen and organic matter are therefore determined.

Soil reaction refers to the degree of acidity or "sourness," alkalinity or "sweetness," and neutrality. This was measured with the use of a Beckman pH meter fitted with a glass electrode. Spurway method (1) was followed in the determination of ammonia and nitrates. Readily available phosphorus was determined by the Truog method (2), available potassium, calcium, magnesium, manganese and iron were determined by the Peach and English methods (3) with the use of a Leitz photoelectric colorimeter provided with suitable light filters. Total nitrogen and organic matter were determined according to the "Methods of Analysis" of the Association of Official Agricultural Chemists of U.S.A. (4), and Black and Walkley methods (5), respectively.

INTERPRETATION OF RESULTS OF CHEMICAL TESTS

Soil reaction or pH value.—Soil reaction simply means the degree of acidity or alkalinity of the soil expressed as the pH value. The scale is from 1 to 14. A pH value of 7 indicates neutrality. Figures below 7 signify increasing acidity while higher values indicate increasing alkalinity.

Soil reaction is a limiting factor in crop production. It affects the concentrations of plant nutrient elements in the soil solution, hence their availability to plants. In very strongly acid soils or

soils of low pH value, concentrations of iron, aluminum, manganese, boron, copper, and zinc are relatively high. These high concentrations are toxic to plants. Nitrogen, potassium, sulfur, calcium, magnesium, and especially phosphorus are less available to plants at low pH values. In very alkaline soils or those with very high pH values, iron, manganese, copper, zinc, and phosphorus become unavailable for plant consumption.

To understand fully the behavior and availability of plant nutrient elements reference is made to Truog's (6) modified version of Pettinger's chart, showing the general trend of the relation of soil reaction to the availability of plant nutrient elements. Reproduction of this chart is made with Truog's accompanying explanations.

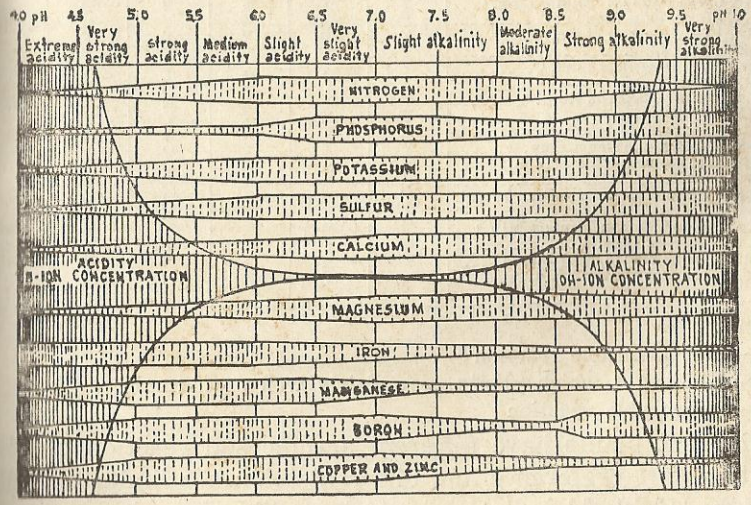

FIG. 31. Chart showing general trend of relation of reaction to availability of plant nutrients.

"The influence of reaction on availability of each nutrient element is expressed by the width of the band (the wider the band, the more favorable the influence) carrying the name of the respective element. Thus, for the maintenance of a satisfactory supply of available nitrogen, for example, a reaction or a pH range of 6 to 8 is the most favorable. This does not mean that if the reaction of a soil falls in this range a satisfactory supply of available nitrogen is assured. All it means is that so far as reaction is concerned, the conditions are

favorable for a satisfactory supply of this element in available form. Also, the narrowed band for nitrogen at pH 5 does not necessarily mean that a deficiency of this element will prevail at that pH. It means that so far as reaction is concerned, the conditions are not favorable for an abundant supply in available form. Other factors than reaction may promote the presence of an abundant supply; moreover, certain crops having a low requirement may be fully satisfied with a low supply."

TABLE 11.—*The pH requirements of some economic plants*

Plant	Soil Reaction					
	Strongly acid pH 4.2–5.4	Medium acid pH 5.5–6.1	Slightly acid pH 6.2–6.9	Neutral reaction pH 7.0	Slightly alkaline pH 7.1–7.8	Medium alkaline pH 7.9–8.5
Abaca, *Musa textiles Nee* [1]	Y	X	X	X	Y	O
Caimito, *Chrysophyllum cainito* Linn. [1]	Y	X	X	Y	O	O
Coffee, *Coffea arabica* Linn [1]	Y	X	X	Y	O	O
Cowpea, *Vigna sinensis* (Linn.) Savi [2]	Y	Y	X	Y	Y	—
Corn, *Zea mays* Linn. [1]	Y	Y	X	X	Y	Y
Durian, *Durio zibethinus* Linn. [1]	Y	X	X	Y	O	O
Peanut, *Arachis hypogaea* Linn. [2]	Y	Y	X	X	O	—
Petsai, *Brassica pekinensis* Rupr. [4]	Y	Y	X	X	X	X
Rice, *Oryza sativa* Linn.[1]	Y	X	X	Y	Y	O
Sugar cane, *Saccharum officinarum* Linn. [2]	O	Y	X	X	X	Y
Tobacco, *Nicotiana tabacum* Linn. [2]	Y	X	Y	O	O	O
Sweet potato, *Ipomoea batatas* (Linn.) Poir [1]	Y	X	X	Y	O	O
Cassava, *Manihot esculenta* Crantz	Y	X	X	X	Y	Y
Pineapple, *Ananas comosus* (Linn.) Merr [1]	Y	X	Y	O	O	O
Banana, *Musa sapientum* Linn. [1]	Y	X	X	X	Y	O
Tomato, *Lycopersicum esculentum* Mill [2]	Y	Y	X	X	Y	Y
Onion, *Allium cepa* Linn. [2]	O	Y	X	Y	Y	Y
Soybean, *Glycine max* (Linn.) Merr [2]	Y	X	X	X	Y	Y
Orange, *Citrus aurentium* Linn. [3]	—	Y	X	X	X	Y

Legend:

X—most favorable reaction

Y—reaction at which plants grow fairly well or normally

O—unfavorable reaction

Different plants have different specific soil reaction requirements or pH preference and different tolerance limits for their growth. Table 11 indicates that plants like rice, pineapple, and

[1] Based from the soil reactions where they are grown with the productivity ratings of the soil types in 11 provinces. A pH range of 5.7 to 6.2 was found to be most suitable for the growth of upland rice, variety *Inintiw*, by Rola, Nena A., and N. L. Galvez, 1949. Effects of soil reaction on the growth of upland rice and on its nitrogen, calcium, phosphorus and iron content. Philippine Agriculturist *33:* 120–125.

[2] Data taken mostly from Weir Wilbert Weir. 1936. Soil Science. Its principles and practice. J.B. Lippincott C. Chicago and Philadelphia.

[3] From Spurway, G.H. 1941. Soil reaction (pH) preferences of plants. Mich. Agr. Expt. Sta. Sp. Bull. 306. Optimum range given was pH 6.0–7.5.

[4] From Arciaga, Antonio M., and N.L. Galvez. 1948. The effect of soil reaction on the growth of petsai plants and on their nitrogen, calcium and phosphorus content. Philippine Agriculturist *32:* 55–59. Normal growth reported was in pH 4.2 to 8.6; optimum range was pH 5.9–8.6.

TABLE 12.—*Chemical characteristics of the different soil types of Palawan Province*

Soil Types	C:N Ratio	Organic Matter	Total Nitrogen	pH Value	Available constituents in parts per million (p.p.m.)						
					Ammonia (NH_3)	Nitrates (NO_3)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Manganese (Mn)	Iron (Fe)
Quingua clay loam	9.27:1	2.56	0.16	5.80		25	21	176	1,600	200	29	trace
Balayan silty clay loam	7.28:1	2.26	0.18	5.65	2	20	27	194	1,400	890	24	21
San Manuel clay loam	12.05:1	3.12	0.15	6.20	5	15	11	56	900	480	11	5
Batangas clay	13.68:1	5.66	0.24	4.70	2	trace	10	56	400	230	50	94
Brodie's clay			0.24	6.30	18	10	8	57	800	800	12	3
Brodie's clay loam			0.18	5.40	2	trace	31	77	2,700	3,000	108	1
Busuanga loam	12.45:1	3.86	0.09	4.80	2	2	7	55	300	200	60	10
Bulalo clay	25.70:1	3.98	0.32	6.08	10		9	109	6,800	1,340	14	trace
Panam sandy clay	9.77:1	5.38	0.10	5.50	2	trace	6	22	1,700	3,080	81	3
Cumalalon clay	19.00:1	3.27	0.13	5.87	2	5	9	89	900	890	26	28
Silad clay	7.52:1	1.68	0.33	6.50	10	trace	24	8	3,000	110	31	trace
Taghorse clay	12.57:1	7.17	0.18	5.90	2	5	8	107	1,800	1,300	67	79
Tagal clay loam	13.30:1	4.13	0.12	5.70	2	2	10	80	2,900	1,450	71	2
Abellin loam	20.20:1	4.18	0.16	6.10	5	trace	31	148	800	550	5	15
Cuyo clay loam	10.02:1	2.81	0.11	5.63	10	10	11	125	500	700	48	6
Bay clay loam	17.70:1	3.35	0.21	7.10	2	trace	5	122	1,300	2,840	73	108
Malatag clay	12.52:1	4.53	0.44	5.90	2	2	5	47	3,500	1,520	74	3
	11.20:1	8.50										

tobacco prefer to grow on medium acid soils (pH 5.5 to 6.1) while other species like alfalfa, sugar cane and orange prefer slightly acid to slightly alkaline reaction (pH 6.2 to 7.8). The pH tolerance limits for the first group of plants mentioned above have been estimated at pH 4.8 to 6.9, while those for the second group are pH 5.5 to 8.5. Although certain plants, like corn and tomato, have rather wide pH tolerance limits (pH 4.8 to 8.5), their optimum requirements are of narrower range (pH 6.2 to 7.0).

The soil reactions of the 17 soil types of Palawan Province vary from pH 4.7 to 7.1 as indicated in table 12. Babuyan clay, Busuanga loam, and Brooke's clay loam are very strongly acidic to strongly acidic (pH 4.5 to 5.4) in reaction. Quingua clay loam, Babuyan silty clay loam, Faraon sandy clay, Guimbalaon clay, Tagburos clay, Tapul clay loam, Coron clay loam and Malalag clay have soil reactions of medium acidity, pH 5.5 to 6. The soil types that are slightly to very slightly acidic in reaction, pH 6 to 7, are San Manuel clay loam, Brooke's clay, Bolinao clay, Sibul clay and Aborlan loam. Bay clay loam is slightly alkaline, pH 7 to 7.5.

Referring to table 11 showing the pH requirements of some economic plants, the soil types most favorable for rice, pineapple and tobacco are Quingua clay loam, Babuyan silty clay loam, Bolinao clay, Faraon sandy clay, Guimbalaon clay, Tagburos clay, Tapul clay loam, Aborlan loam, San Manuel clay loam and Sibul clay. These crops grow fairly well or normally on Babuyan clay, Brooke's clay loam and Busuanga loam. Rice, tobacco and pineapple may grow also normally on Bay clay loam.

Nitrogen.—The average total nitrogen content of Philippine cultivated soils (surface soils) so far analyzed was about 0.14 per cent. Babuyan clay, Busuanga loam, Faraon sandy clay, Guimbalaon clay, Tapul clay loam and Coron clay loam are below the average total nitrogen content of Philippine soils. Ten to twenty-five p.p.m. (0.001 to 0.0025 per cent) of ammonia and nitrates are considered as normal supply of nitrogen.

Referring to table 12, all the soil types analyzed are in need of nitrogen for most crops. For rice and tobacco on Quingua clay loam and Babuyan silty clay loam, nitrogen supply is adequate. However, top dressing of nitrogenous fertilizer is necessary for vegetative growth.

Organic matter, such as farm manures, green manures, crop residues and nitrogenous commercial fertilizers are the principal sources of nitrogen. Nitrifying micro-organisms have the ability to fix atmospheric nitrogen for plant use. During thunderstorms, atmospheric nitrogen is oxidized to nitrate form and carried down by the rain as nitric acid.

Plants normally use nitrogen in the nitrate form. However, there are several crops as rice and other grain crops that feed on the ammonium form, which has a great advantage over the nitrate form. It is loosely fixed to clay particles and to humic compounds of the soil and released into the soil moisture only when its ammonium content becomes low. The nitrate form is not fixed in the soil and, therefore, is easily leached or carried away from the soil by surface water especially on coarse and porous soils.

Nitrogen is considered as the most important factor in plant growth. It is found in numerous forms in plants. Two to four per cent of the dry weight of plants is nitrogen. It is the basic constituents of the protoplasms of cells, proteins and chlorophyll. Shortage of nitrogen results in stunted growth and sickly yellowing of leaves. Cellulose, sugars, starches and fats formations within the plants are very much reduced. Excess supply of nitrogen, on the other hand, results not only in excessive growth but also lodging in rice, oat, barley, and wheat, less resistant to plant diseases, lowering purity of cane juice in sugar cane and weaker fibers in fiber plants.

Soil Organic Matter.—Organic matter is an important constituent of the surface soil. Without it, a soil is poor and unproductive. It exerts a controlling influence on soil properties, namely: (*a*) better tilth, aeration and drainage, (*b*) higher water holding capacity, hence sufficient moisture for plant and micro-organisms during dry season and lesser erosion due to less volume of runoff, and (*c*) higher fertility because of the liberation of nutrient elements during the decomposition of the organic matter. Humus is highly colloidal in nature. Humus as clay, functions as an acidoid or micelle and usually carries a large number of negative charges. The mineral micelles are composed principally of silicon, oxygen, aluminum, and iron, while humus is chiefly composed of carbon, hydrogen, oxygen, nitrogen, sulfur and phosphorus.

The conversion of organic matter into humus is a biochemical process so that any unfavorable conditions that affect the micro-

bial activities will certainly decrease the rate of organic matter decomposition. The kind, age and chemical composition of the plants, soil aeration, reaction and fertility, and soil moisture and temperature are some of the important factors affecting the rate of organic matter decay.

The sources of soil organic matter are mainly from the roots, leaves and stems of plants, farm manures, green manures, and dead bodies of animals and micro-organisms. Leguminous crops provide the soil not only soil organic matter but also more nitrogen than non-leguminous plants because they have the ability to fix nitrogen in the soil and contain more nitrogen in proportion to their carbon content.

The carbon-nitrogen (C:N) ratio in fresh materials which are commonly added to soil is about 80:1 in mature straw and 12:20.1 in leguminous green manure crops. These ratios become narrower in a relatively short time after these materials have been thoroughly incorporated in the soil. The C:N ratio of humus in mineral soils is roughly 10:1 which means that for every pound of nitrogen, there exist 10 pounds of carbon.

A narrow C:N ratio is obtained when there is a low percentage of carbon and a high percentage of nitrogen. A high percentage of carbon and a low percentage of nitrogen, on the other hand, gives a wider C:N ratio. Referring to table 12, Babuyan silty clay loam has the narrowest ratio, 7.28:1 and the widest ratio, 25.70:1, is represented by Busuanga loam.

The determination of soil organic matter is usually based on organic carbon analysis. The amount of organic carbon is usually related to the total nitrogen content. The higher the percentage of nitrogen, the higher the percentage of the organic matter of the soil. In table 12, this relationship is shown in the analysis of Malalag clay, Sibul clay and Bolinao clay for their total nitrogen and organic matter contents.

Phosphorus.—The available phosphorus, 30 to 40 p.p.m. (0.003 to 0.004 per cent) seem to be the normal requirements for rice and other grain crops under Philippine conditions. For some Philippine soil types, there are indications that 30 to 40 p.p.m. of available phosphorus are sufficient to maintain a good crop of rice and other grain crops.

Only Brooke's clay loam and Aborlan loam contain the normal requirements of phosphorus for rice and other crops. Nevertheless, 50 kilograms of superphosphate are recommended for both of these soil types. The remaining 15 soil types are definitely in need of phosphate fertilizer.

The phosphatic commercial fertilizers are the main sources of phosphorus. Guano, bone meal, fish meal, rock phosphate, and basic slag contain also phosphorus in varying amounts. The phosphorus must be also in the water soluble form to be of agricultural value. Phosphorus is an immobile element and easily fixed in the soil by the formation of insoluble iron, manganese and aluminum phosphates. These phosphates are not completely insoluble, however, as there are small quantities circulating in the soil moisture. The higher the phosphate content of the soil, by the application of excess phosphatic fertilizer, the higher the concentration of phosphorus in the soil solution because the precipitating power of iron, aluminum and manganese is satisfied. Besides, plant root hairs have the ability to dissolve the fixed phosphorus within the sorption area. The addition of organic matter in the soil increases also the availability of phosphorus. The humic compounds or organic acids derived from the decomposition of organic matter combined with the soil's iron, manganese and aluminum forming stable compounds and thus phosphorus is released into the soil solution.

Like nitrogen, phosphorus is an important cell constituent. It is therefore an important growth factor. It is concentrated in all the growing parts of a plant, such as root-tips, buds, shoot-tips and seedlings. Deficiency of phosphorus likewise results in stunted and abnormal growth. Purpling of leaves and stem of corn; stunted growth and purplish-green leaves of legumes, and delayed maturity and dark green color of tobacco are some manifestations of phosphorus shortage.

Phosphorus is also necessary for the assimilation of fats, development of root systems, transformation of carbohydrates, as in the conversion of starches into sugars, grain formation, and uptake of potassium. It hastens maturity, and tends to counteract the bad effects of excess nitrogen.

Potassium.—For most crops, 100 to 150 p.p.m. (0.01 to 0.015 per cent) of available potassium seem to be an adequate supply of potassium in the soil. Bolinao clay, Tagburos clay, Aborlan loam, Coron clay loam and Bay clay loam are within this range of potassium adequacy in the soil, but still need potash fertilizer application to insure enough supply of available potassium. Quingua clay loam and Babuyan silty clay loam contain sufficient

amounts of potassium. The rest of the soil types are low in their potassium content, hence application of potassic fertilizers is necessary.

Unlike phosphorus, potassium is a highly mobile nutrient element, very soluble in the soil moisture and does not combine with other elements to form very insoluble compounds. It is easily leached and lost from the soil, except when fixed by mineral clay soils. Potassium is neither a constituent of plant cells nor found in large amounts in sugars, fats, proteins and starches.

In case of insufficient supply of available potassium, plant growth is also stunted. It is also concentrated in root tips, plant tops, buds, flowers, and in coffee bean, cocoa, tomatoes, citrus and pineapples. Deficiency of this element may lead to small fruits and grains. Sugar cane, peanuts, rice and other grain crops, bananas, potatoes, cassava, coconuts, tobacco and other crops require liberal amounts of potassium. Sufficient amount of potassium increases plumpness in grains. Deficiency of potassium weakens the stalks of grain crops, resulting in lodging; lessens plant disease resistance; weakens cotton, abaca and ramie fibers; increases transpiration of the plant so that wilting takes place during dry weather. It also weakens the stalks of leaves and fruits causing early defoliation and fruit drop.

Where the soil is highly deficient in available potassium small applications of potassic fertilizer generally will not give immediate significant increase in crop yield because of the fixation of the added potassium in the base exchange complex of the soil. However, large initial applications of potassic fertilizer on such a soil will satisfy or saturate its potassium-fixing-capacity and leave enough readily available potassium for the immediate needs of plants. It was also found that on San Manuel silt loam which contain 161 p.p.m. of available potassium, repeated large applications of potassic fertilizer did not give at all any significant increase in yield, using *Guinangang* rice as the crop indicator. Experiments on potash fertilization of sugar cane in various haciendas at Victorias, Occidental Negros by Locsin (10) reported that soils containing 85 p.p.m. or less of available potassium, as determined by the Peech and English method, gave positive crop response to potash applications while soils containing 151 p.p.m. or more of available potassium gave negative crop response.

As potassium is a highly mobile nutrient, deficiency symptoms appear in the older leaves. The tips and margins of the leaves turn yellow and brownish progressing towards the midrib. Brown spots appear in tobacco leaves in potassium deficiency.

Calcium.—Brooke's clay loam, Bolinao clay, Sibul clay, Tapul clay loam and Malalag clay need no lime application as their analysis indicate high content of calcium and magnesium. However, for "high lime" crops as sugar cane, alfalfa and other legumes, moderate split lime applications are advantageous. The rest require liming.

Calcium affects the soil physically, chemically and biologically. It improves soil structures, hence better tilth, drainage and aeration. Calcium, as a liming material, neutralizes the acidity of acid soils and corrects the toxic conditions caused by soil acidity. It also affects the behavior and availability of nutrient elements as have been previously explained. It controls the uptake of moisture and balances the toxic effects of potassium, magnesium, sodium and boron. Calcium is built into the cell-walls to form a protective sieve for the nutrients to seep through in passing into the cells. It acts as a binding agent between the walls of the cells to hold them together.

Biologically, calcium promotes decomposition of organic matter, favorable conditions for nitrification and for the growth and functioning of both symbiotic and non-symbiotic nitrogen-fixing bacteria.

Liming has increased the: (a) calcium content of cabbage leaves from 4.42 per cent to as much as 7.53 per cent, (b) the yield of tomatoes to more than double together with Vitamin C or Ascorbic acid content, and (c) corn grain to 40 per cent of the protein content. Madamba and Hernandez (13) in their experiment in the effect of lime found that the increased yield of upland rice was due to the application of lime.

Calcium is very immobile in the plant sap. Deficiency symptoms of calcium, therefore, appear first in the terminal buds, plants tops and root-tips and then to the older parts of the plants.

Magnesium.—Soil types that rated high in crop productivity had been analyzed about 600 to 1,700 p.p.m. of available magnesium on the average. However, for certain species of citrus (pummelo or *Citrus maxima*), symptoms of magnesium deficiency had been observed in soils that contained even as much as 950 p.p.m. of available magnesium. Table 12 shows that

Babuyan silty clay loam, Brooke's clay, Brooke's clay loam, Bolinao clay, Faraon sandy clay, Guimbalaon clay, Tagburos clay, Tapul clay loam, Coron clay loam, Bay clay loam, and Malalag clay are above the 600 p.p.m. level and they are rated average and high in magnesium content. The remaining soil types fall below the 600 p.p.m. level and so considered as magnesium deficient soils. The addition of magnesium carbonate, magnesium sulfate or dolomitic limestone corrects this deficiency.

The necessary constituent of chlorophyll is magnesium. Chlorophyll, the green pigment in plants, makes photosynthesis and, therefore, plant life possible by trapping the energy from the sun. Deficiency of magnesium affects the function of chlorophyll. Premature defoliation of the plant, discoloration of leaves as purplish-red with green veins of cotton, chlorosis of tobacco known as "sand drown" and striped leaves of corn, with the veins remaining green but the areas between the veins are yellow, are some symptoms of magnesium deficiency. In legumes, the deficiency is shown by chlorotic leaves. Magnesium shortage in citrus causes a reduction in crop yield, size of the fruit, and the sugar, acid and Vitamin C content of the juice.

Manganese.—Manganese is one of the trace elements needed by plants. Agricultural soils generally contain very small amounts of total manganese, less than 0.1 per cent or 100 p.p.m., but the requirements of plants are so minute that they are usually satisfied. Manganese and the other trace elements function as catalysts in plant metabolism. The manganese contents of the following crops as reported in literature are cabbage leaves, 34 p.p.m.; raddish roots, 29 p.p.m.; rice grain, 23 p.p.m.; and tomato fruits, 46 p.p.m.

Soil types from various parts of the Philippines which were rated high or at least medium in crop productivity which had been analyzed for available manganese contain from about 15 to 250 p.p.m. In table 12, San Manuel clay loam, Brooke's clay, Bolinao clay and Aborlan loam have low manganese content ranging from 5 to 14 p.p.m. The remaining soil types are not in need of manganese fertilizer.

Deficiency of manganese, iron and boron usually occurs in calcareous and heavy limed soils due to the formation of their insoluble carbonates. Dwarf tomatoes, beans, oats, tobacco and various other plants are found in soils whose manganese content is very low. Their leaves are chlorotic and finally become spotted. The "gray speck" of the roots is due to

manganese shortage in some soils. Onion leaves curl and the bulb remains immature at harvest time. Celery becomes yellow and spinach, lettuce, and potatoes are chlorotic.

Iron.—Although the total iron content of an average agricultural soil goes as high as 50 p.p.m. or more, the amount of available iron to plants is very small. Representative soil types from various parts of Luzon which rated high or at least medium in crop productivity were found to contain from 2 to 30 p.p.m. of available iron. Table 12 shows that only 7 soil types are not within the range. Quingua clay loam, Brooke's clay loam, Bolinao clay and Sibul clay are deficient in available iron, while Babuyan clay, Tagburos clay and Bay clay loam are rather high in available iron.

In neutral and alkaline soils, iron is very insoluble that some plants have difficulty in assimilating enough for their requirements. Likewise, in medium acid to extremely acid soils, it combines with soluble phosphates and is precipitated as insoluble iron phosphates, a form unavailable to plants. The formation of iron phosphates occurs both in acid and alkaline soils. It is more likely to happen in sandy than in clay soils, because clay soils have greater power to fix excess soluble phosphate. Iron deficiency can be corrected by the application of iron bearing fertilizers, as ferrous sulfate.

FERTILIZER AND LIME REQUIREMENTS

Nature's supply of plant nutrients is not inexhaustible. It is also seldom found proportionately balanced for proper plant growth. The multifarious activities of man for his livelihood, comfort and convenience deplete the soil's mineral and organic resources.

To compensate for the continuous depletion of the soil's fertility and to have plant nutrients balance, the use of chemical fertilizers and agricultural lime is becoming popular effective means for good soil management. Their use, however, may not insure positive results for under unfavorable conditions, plants cannot fully utilize them. Besides, soil fertility depends not only upon the quantity of available nutrients in the soil but also based from various factors namely: (a) temperature, (b) drought, (c) plant diseases, (d) insect damages, (e) poor drainage and aeration, (f) soil texture, (g) antagonism of

one element upon the uptake of another, and (h) agricultural management practices.

The general fertilizer and lime recommendations, based from the chemical analysis, for upland and lowland rice, coconut, corn and tobacco for each soil type are indicated in table 13. The commercial fertilizers used for these recommendations are the single element fertilizers. However, any other kinds or grades of fertilizers other than those recommended can be substituted provided that the nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) in the recommended fertilizers are supplied. The lime recommended is agricultural lime. It is calcium carbonate or limestone pulverized to 20 mesh and about 50 per cent to pass 100 mesh. Calcium oxide (CaO) or burnt lime can be used but the amount is about 0.56 times that of the recommended agricultural lime. Lime corrects soil acidity and supplies calcium element. For relatively high lime requirements, split applications are preferable than one heavy application.

Algae has the same fertilizer and lime requirements as that of lowland rice. For garlic and onion, a trial of 250 kilograms per hectare of soil sulphaid, analyzing 2 per cent sulfur is recommended in addition to the fertilizer and lime requirements. Sulfate of potash (K_2SO_4) analyzing 50 per cent (K_2O) is recommended for tobacco in lieu of muriate of potash (KCl). The chlorine content of this potash fertilizer has a burning effect on the leaves of the plants, reducing its quality and corresponding decrease in yields.

Brooke's clay loam, Bolinao clay, Sibul clay and Tapul clay loam have high calcium contents ranging from 2,700 to 6,800 p.p.m. These soil types need not be limed. Extreme acidity and a rather low calcium content of the soil indicate the need for liming especially for sugar cane, alfalfa and leguminous crops. The remaining 12 soil types need liming. Their calcium contents and pH value or soil reactions which range from 400 to 1,800 p.p.m. and from 4.7 to 7.1, respectively, require lime from 1 to 8 tons per hectare for upland rice, corn, ginger and onion, and from 0.50 to 4 tons per hectare for lowland rice, algae, coconut, castor beans, papaya, black pepper and tobacco.

Quingua clay loam and Babuyan silty clay loam contain sufficient amounts of available nitrogen for rice. For better yields, however, top dressings of nitrogen fertilizer are essential for vegetative growth. The other soil types are definitely in need

TABLE 13.—*Fertilizer and lime requirements of the different soil types of Palawan*

Soil Types	Agricultural lime Ton/Ha.	Ammonium Sulfate (20% N) Kg./Ha.	Superphosphate (20% P_2O_5) Kg./Ha.	Muriate of Potash (60% K_2O) Kg./Ha.
		For upland rice		
Quingua clay loam	2.00	----------	150	----------
Babuyan silty clay loam	3.00	----------	100	----------
San Manuel clay loam	5.50	200	250	200
Babuyan clay	8.00	200	250	200
Brooke's clay	4.00	200	250	250
Brooke's clay loam	----------	200	50	150
Busuanga loam	8.50	200	300	200
Bolinao clay	----------	200	250	100
Faraon sandy clay	1.50	200	300	250
Guimbalaon clay	5.50	200	250	100
Sibul clay	----------	200	100	300
Tagburos clay	1.00	200	250	100
Tapul clay loam	----------	200	250	150
Aborlan loam	6.00	200	50	50
Bay clay loam	3.50	200	300	50
		For lowland rice		
Quingua clay loam	1.00	----------	150	----------
Babuyan silty clay loam	1.50	----------	100	----------
San Manuel clay loam	2.75	200	250	200
Babuyan clay	4.00	200	250	200
Brooke's clay	2.00	200	250	250
Busuanga loam	4.25	200	300	200
Bolinao clay	----------	200	250	100
Faraon sandy clay	0.75	200	300	250
Guimbalaon clay	2.75	200	250	100
Sibul clay	----------	200	100	300
Tagburos clay	.50	200	250	100
Tapul clay loam	----------	200	250	150
Aborlan loam	3.00	200	50	50
Bay clay loam	1.75	200	300	50
		For Coconut		
Quingua clay loam	1.00	100	150	----------
Babuyan silty clay loam	1.50	100	100	----------
San Manuel clay loam	2.75	300	250	200
Babuyan clay	4.00	300	250	200
Brooke's clay	2.00	300	250	250
Brooke's clay loam	----------	300	50	150
Busuanga loam	4.25	300	300	200
Bolinao clay	----------	300	250	100
Faraon sandy clay	0.75	300	300	250
Guimbalaon clay	2.75	300	250	100
Sibul clay	----------	300	100	300
Tagburos clay	0.50	300	250	100
Tapul clay loam	----------	300	250	150
Aborlan loam	3.00	300	50	50
Coron clay loam	3.75	150	250	50
Bay clay loam	1.75	300	300	200
Malalag clay	----------	300	300	200
		For corn		
Quingua clay loam	2.00	100	150	----------
Babuyan silty clay loam	3.00	100	100	----------
San Manuel clay loam	5.50	300	250	250
Babuyan clay	8.00	300	250	250
Brooke's clay	4.00	300	250	250
Brooke's clay loam	----------	300	50	200
Busuanga loam	8.50	300	300	250
Bolinao clay	----------	300	250	150
Faraon sandy clay	1.50	300	305	350
Guimbalaon clay	5.50	300	250	150
Sibul clay	----------	300	100	450
Tagburos clay	1.00	300	250	150
Tapul clay loam	----------	300	250	200
Aborlan loam	6.00	300	50	50
Bay clay loam	3.50	300	300	100

TABLE 13.—*Fertilizer and lime requirement of the different soil types of Palawan.*—Continued

Soil Types	For Tobacco (Native)			
	Agricultural lime Ton/Ha.	Ammonium Sulfate Kg./Ha.	Superphosphate (20% P_2O_5) Kg./Ha.	Sulfate of Potash (50% K_2O)
Quingua clay loam	1.00	50	150	----------
Babuyan silty clay loam	1.50	50	100	----------
San Manuel clay loam	2.75	200	250	480
Babuyan clay	4.00	200	250	480
Brooke's clay	2.00	200	250	480
Brooke's clay loam	----------	200	50	360
Busuanga loam	4.25	200	300	480
Bolinao clay	----------	200	250	240
Faraon sandy clay	0.75	200	300	600
Guimbalaon clay	2.75	200	100	720
Tagburos clay	0.50	200	250	360
Tapul clay loam	----------	200	250	360
Aborlan loam	3.00	200	50	60
Bay clay loam	1.75	200	300	120

Soil Types	For Tobacco (Virginia)			
	Agricultural lime Ton/Ha.	Ammonium Sulfate Kg./Ha.	Superphosphate (20% P_2O_5) Kg./Ha.	Sulfate of Potash (50% K_2O)
Quingua clay loam	1.00	----------	150	----------
Babuyan silty clay loam	1.50	----------	100	----------
San Manuel clay loam	2.75	100	250	480
Babuyan clay	4.00	100	250	480
Brooke's clay	2.00	100	250	480
Brooke's clay loam	----------	150	50	360
Busuanga loam	4.25	100	300	480
Bolinao clay	----------	150	250	240
Faraon sandy clay	0.75	150	300	600
Guimbalaon clay	2.75	150	250	240
Tagburos clay	0.50	150	250	120
Tapul clay loam	----------	150	250	360
Aborlan loam	3.00	150	50	600
Bay clay loam	1.75	150	300	120

of nitrogenous, phosphatic, and potassic fertilizers except Quingua clay loam and Babuyan silty clay loam having sufficient amounts of potassium. Bay clay loam, Bolinao clay, Tagburos clay and Aborlan loam appear well supplied with potassium but still need potassic fertilizer.

In crop production, manures and commercial fertilizers must not be used singly. They should be used in combination because each serves different purposes. Building and maintaining the organic content of the soil are the primary functions of manures as their nutritive elements are deficient, variable and proportionately unbalanced. To use them alone is, therefore, bulky and costly. The supply is also inadequate. Besides, organic matter must undergo complete decomposition before it can serve its functions in the soil. Decomposition requires great amounts of oxygen to the extent that heavy soils which are poorly aerated

and drained are completely devoid of oxygen, which is needed by plant roots for their growth, developments and to perform their vital functions. Lack or absence of oxygen in the soil inhibits proper growth of plants and so adversely affects crop yields. When heavy manuring is imperative, however, it is preferable to disc the manure lightly rather than plow it under. This way oxygen shortage is avoided.

On the other hand, chemical fertilizers, especially the complete mixtures, are not only sufficient and cheaper, considering into account the cost of handling and labor, but also contain high and balanced nutrient elements which are readily available for immediate plant needs.

Commercial single fertilizers and fertilizer mixtures carry the three major plant nutrients as percentages of N for nitrogen, P_2O_5 for phosphorus, and K_2O for potassium. Fertilizers are classified as nitrogenous, phosphatic and potassic fertilizers depending on what nutrient element is contained in them.

The nitrogenous fertilizers offer their nitrogen in ammonium (NH_4) and nitrate (NO_3) forms. Ammonium sulfate, ammonium phosphate, and urea belong to the ammonium form, while potassium nitrate and sodium nitrate represent the nitrate form. Guano and fish meal are some of the organic fertilizers, having their nitrogen in the organic form.

The phosphatic fertilizers are water insoluble and water soluble compounds; rock phosphate, basic slag, and guano are water insoluble, and, therefore, are used preferably in acid soils because they are soluble in them. Rock phosphate and basic slag are alkaline in reaction and when applied in the soil correct the unfavorable acidity of acid soils. The superphosphates, such as the ordinary, double, and triple superphosphates, have their phosphates in the monocalcium forms which are very highly soluble in water. The phosphates of ammonium phosphates (Ammophos) is also in the water soluble form. The ordinary superphosphate contains large amounts of calcium sulfate, gypsum, supplying the soil with calcium and sulfur in adequate quantities for plant nutrition. The double and triple superphosphates contain negligible amount of sulfur but have sufficient calcium to meet the calcium demands for most crops. The ordinary and double superphosphates are non-acid forming materials.

Muriate of potash is most commonly used as a fertilizer. It contains 60 per cent K_2O. Potassium sulfate, analyzing 50 per cent K_2O, is also a source of potassium. It is especially used in the fertilization of tobacco plants as it possesses no burning effect on the leaves. Both of these salts are highly water soluble and acid forming fertilizers.

Factors to be considered in lime and fertilizer applications: (1) Uniformity of distribution.—Fertilizer materials must be thoroughly and uniformly distributed in the soil by the use of farm implements. Granulated or pelleted fertilizers are preferable to the powdered forms due to their ease with which they can be evenly distributed in the soil. The powdered forms are subject to caking due to rapid absorption of moisture and to segregation of their component particles of different sizes and densities during bagging and transporting them. Under these conditions the powdered forms cannot be well mixed with the soil. (2) Placement of the fertilizer.—As a general rule, the fertilizer materials are placed within the reach of the active roots of the plants. In fertilizing shallow rooted crops, such as rice, corn, tobacco, and vegetables, the fertilizer is placed near the plant or at seed level. Fixation of phosphorus is greatly minimized as well as the nutrient element is readily within the sorption area of the root system of the plants. For crops whose roots develop vertically, it is wise to place the fertilizer below the seed level. This will insure the passing of the roots thru the fertilized area. The potassic fertilizer is placed not too close or in contact with the roots to avoid the burning of the roots. Burned roots result in stunted growth, lower yields, and poorer quality of crops. (3) Time element.—The field to be fertilized should contain sufficient moisture. It is best to apply fertilizer when the leaves of the plants are dry to do away with the burning of the leaves. Lime is applied at least one month before planting and it should not be mixed with nitrogenous fertilizers. Calcium nitrate, calcium cyanide and basic slag should not be mixed with the superphosphates. The reason is to avoid unfavorable chemical reactions that take place when mixed together.

Miscellaneous Chemical Analyses

Silica sand.—The analysis of silica sand as found in Del Pilar and in the shores of Imuruan Bay gave as high as 98 per cent silicon dioxide. Silica sand is found in most of the sea coast of northern Palawan although they are not as extensive as those in the two places named.

Palawan sand.—In many of the shores of the islands as well as sand bars and shoals in the southern part of Palawan are rich deposits of white and finely ground marine shells which are now classified as Palawan sand. Sand from these areas analyzes 95 per cent calcium carbonate. These are good sources of agricultural lime for the acid soils of the province.

SOIL TEXTURES AND MECHANICAL ANALYSIS OF PALAWAN SOILS

A lump of soil contains particles of varying sizes. There are at least three sizes based on the diameter of the soil particle. Each of these particles is called soil separate. The sizes of the soil separates range from 2.00 to 0.05 millimeters for all kinds of sand; 0.05 to 0.002 millimeter for silt; and, any material finer than 0.002 millimeter for clay. Some very pure sandy soils may not contain clay particles and similarly for pure clays which may contain very little of sand particles. The proportion in the content of sand, silt, and clay in a soil will determine its textural class, such as sandy loam, silt loam, loam, sandy clay, silty clay, clay loam, or clay.

The soils in Palawan are characterized by their practically fine texture which range from sandy clay, silty clay, loam, clay loam to clay. There are many instances where the soil types are clay. There are only two loam types. The coarse textures are limited only to the beach sand or soils along the coastal shores. The degree of fineness of soil is sometimes used as a basis for determining development of soils. Soils with finer textures are more developed than those with coarser textures.

In the lowland soils, a total of 15,450 hectares of loam; 72,150 hectares of clay loam; and, 30,750 hectares of clay were delineated. Similarly for upland soils, the total for clay loam is 229,500 hectares, sandy clay loam 27,000 hectares and for clay 177,050 hectares. As a whole, 14.09 per cent of the area surveyed is clay and 22.31 per cent is clay loam. The data above on hectarage do not cover the entire area of the province since 83,420 hectares or about 5.65 per cent remain unclassified.

KEY TO THE SOIL TYPES OF PALAWAN PROVINCE

SOIL TYPE	Relief	Drainage	Permeability	Suitability	Conservation Practices
Aborlan loam (608) San Manuel clay loam (236) Quingua clay loam (109) Busuanga loam (695)	Level	Good	Moderate	Lowland rice, corn, coconut, fruit trees.	Green manuring, liming and fertilization.
Bay clay loam (23) Babuyan silty clay loam (654) Babuyan clay (694) Brooke's clay (604) Brooke's clay loam (605)	Level	Very poor	Very slow	Lowland rice, and other crops if drained.	Drainage, green manuring, liming and fertilization.
Bolinao clay (153) Sibul clay (14) Faraon sandy clay (702)	Rolling to hilly	Good	Moderate	Coconut, citrus, fruit trees, corn on suitable relief.	Green manuring and fertilization.
Guimbalaon clay (205) Tapul clay loam (459) Tagburos clay (693)	Rolling to hilly	Good	Moderate	Upland crops on less grades. Trees on steep sides.	For crops building up soil by fertilization and green manuring, and erosion control.
Coron clay loam (681) Malalag clay (716)	Hilly	Good	Slow	For forest only----------	For forest or pasture only.

MECHANICAL ANALYSIS OF PALAWAN SOILS

The mechanical analysis of these soils are shown in table 14. Mechanical analysis shows the proportionate amount of the sand, silt, and clay fractions that make up the soil. The mineral particles of sand include sizes from 2.00 to 0.05 millimeters in diameter, silt from 0.05 to 0.002 millimeters and clay for particles smaller than 0.002 millimeters in diameter. Depending upon the relative amounts of these different aggregates, soils may be classed as sand, sandy loam, loam, silt loam, clay loam, or clay. Soils with less than 20 per cent clay are sand, loamy sand, sandy loam, loam, and silt loam. Soils that contain from 20 to 40 per cent clay are clay loam and silty clay loam. Soils with more than 40 per cent clay are classed as clay.

Total colloids represent the clay fraction as well as the ultramicroscopic mineral and organic particles in the soil. The colloids are the most important and dynamic features of the soil. They affect the physical and chemical properties of soils as well.

TABLE 14.—*The proportionate amount of sand, silt, and clay; and total colloids in the surface soil of Palawan soils*[1]

Soil Type No.	SOIL TYPE	Sand per cent	Silt per cent	Clay per cent	Total Colloid per cent
23	Bay clay loam	27.2	36.0	36.8	45.8
236	San Manuel clay loam	39.2	34.4	26.4	33.3
608	Aborlan loam	41.8	34.0	24.2	33.8
695	Busuanga loam	50.9	28.5	20.6	35.3
654	Babuyan silty clay loam	15.7	46.4	37.9	52.1
694	Babuyan clay	5.2	34.8	60.0	81.4
604	Brooke's clay	27.0	22.5	51.5	49.0
605	Brooke's clay loam	16.0	55.8	28.2	54.6
109	Quingua clay loam	21.3	48.5	30.2	43.3
153	Bolinao clay	19.7	28.1	52.2	69.6
14	Sibul clay	15.4	33.5	51.1	62.0
702	Faraon sandy clay	55.2	22.8	22.0	27.4
681	Coron clay loam	47.9	18.8	33.3	39.8
459	Tapul clay loam	37.5	27.2	35.3	44.2
693	Tagburos clay	45.1	11.5	39.4	44.3
716	Malalag clay	21.9	26.6	51.5	61.2
205	Guimbalaon clay	33.3	17.9	48.8	55.7

[1] The modified Bouyoucos system of mechanical analysis was used.

FIELD DETERMINATION OF SOIL TEXTURAL CLASS

The determination of the class is still made in the field mainly by feeling the soil with the fingers. While this requires skill and experience, accuracy can be had if the field scientist frequently checks it against laboratory results.

The following are the definitions of the basic soil textural classes in terms of field experience and feel:

Sand.—Sand is loose and single-grained. The individual grains can readily be seen or felt. Squeezed in the hand when dry, it will fall apart when the pressure is released. Squeezed when moist, it will form a cast, but will crumble when touched.

Sandy loam.—Sandy loam is a soil containing much sand with enough silt and clay to make it somewhat coherent. The individual sand grains can be readily seen and felt. Squeezed when dry, it will form a cast which readily falls apart, but if squeezed when moist, a cast can be formed that will bear careful handling without breaking.

Loam.—Loam is a soil having relatively even mixture of different grades of sand, silt, and clay. It is mellow with a somewhat gritty feel, yet fairly smooth and slightly plastic. Squeezed when dry, it will form a cast that will bear careful handling, while the cast formed by squeezing the moist soil can be handled quite freely without breaking.

Silt loam.—Silt loam is a soil having a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called "silt." When dry it may appear cloddy but the lumps can be readily broken, and when pulverized it feels soft and floury. When wet the soil readily runs together and puddles. Either dry or moist, it will form casts that can be freely handled without breaking, but when moistened and squeezed between the fingers, it will not "ribbon" but will give a broken appearance.

Clay loam.—Clay loam is a fine-textured soil which usually breaks into clods or lumps that are hard when dry. When the moist soil is pinched between the thumb and fingers, it will form a thin "ribbon" which will break readily, barely sustaining its own weight. The moist soil is plastic and can be formed into a cast that will bear much handling. When kneaded in the hand it does not crumble readily but tends to work into a heavy compact mass.

Clay.—Clay is a fine-textured soil that usually forms into very hard lumps or clods when dry. It is quite plastic and usually sticky when wet. When the moist soil is pinched out between the thumb and fingers, it will form a long, flexible "ribbon." Some fine clays very high in colloids are friable and lack plasticity under all conditions of moisture.

Such definitions are suggestive only. None could be made in these or similar terms that would apply adequately to all soils. The dependable definitions, the standards, are those developed from mechanical analyses.

MORPHOLOGY AND GENESIS OF PALAWAN SOILS

Soil is the product of rock weathering. Weathering takes place under the influence of rainfall, temperature, and living organisms. The rocks are of different kinds, and forces of weathering also vary considerably so that the end product—the soil—will naturally assume various physical characteristics.

The soils in Palawan are mainly products of rock weathering. Soils thus formed are called primary soils. Such soils are found in all the upland, hilly, and mountainous areas. The secondary or transported soils are those that were displaced from their original sites and usually deposited in lowlands as plains. These soils are like those on the plains of Panacan, Aborlan, Ilian, Barbacan, and other valleys.

Since soil formation begins when rocks start to disintegrate, it follows that the nature of the rock is one of the determining factors in the kind of soil produced. Generally, rocks rich in mineral elements produce fertile soils. A large proportion of the rock formations in Palawan are metamorphosed igneous rocks. This means that igneous rocks have undergone physical changes making them much harder in consistency. Hard rocks require more intense forces and longer time for weathering than softer ones. For this reason many soils in Palawan are shallow and low in fertility. The rocks or parent materials from which the soils of Palawan were derived are classified as follows:

Igneous	*Sedimentary*	*Metamorphic*
Andesite—Guimbalaon	Limestone—Faraon	Quartz, Gneiss, Chert—Coron
Andesite—Tagburos	Limestone—Bolinao	Chert—Malalag
Granite—Tapul	Limestone—Sibul	Chert—Mountain soils

The secondary soils in Palawan are basically of unconsolidated parent materials, clay, silt, and sand.

The profiles developed from the weathering of andesites and granites like those of the Guimbalaon, Tagburos, and Tapul series are all deep. This condition is to be expected because

the rocks from which they were formed are fairly soft. On the other hand, the profiles of Coron, Malalag, and other mountain soils produced from quartzites, gneiss, and cherts, which are all very hard rocks, are shallow and low in fertility.

The soils on all the plains of Palawan were formed as a result of erosion and deposition of soil materials from the hills and mountains. Generally, since these transported soils were basically low in fertility at their original place of formation, most soils of the plains in the province are also poor.

Soils of the Faraon, Sibul, and Bolinao series were formed from limestone. These soils are fairly good and are usually rich in bases like calcium. Although limestone is easily decomposed the profile developed from it is shallow. Usually, only the surface soil or "A" horizon is present. The "B" horizon is not visible. Soil formation in this case is rather fast so that the transition step is sometimes lacking.

The profile characteristics of the soils in Palawan may be classified according to their degree of development as follows:

PROFILE GROUP I

Soils of recent alluvial fans and flood plains having undeveloped profiles underlain by unconsolidated materials belong to this group, like:

1. Beach sand.

PROFILE GROUP II

These are soils of young alluvial fans and flood plains having slightly developed profiles underlain by unconsolidated materials, such as:

1. San Manuel series, and
2. Quingua series.

PROFILE GROUP III

Soils of older alluvial fans or terraces having moderately developed profiles underlain by unconsolidated materials are found in this group, such as:

1. Bay series;
2. Aborlan series; and,
3. Busuanga series.

PROFILE GROUP IV

Soils on older plains or terraces having strongly developed profiles underlain by unconsolidated materials belong to this group, such as:

1. Babuyan series, and
2. Brooke's series.

PROFILE GROUP V

Soils on older plains or terraces having hardpan subsoil or lower subsoil generally underlain by consolidated materials are found in this group. Not any of the soils of Palawan belong to this group.

PROFILE GROUP VI

Soils on older terraces and upland areas having dense clay subsoil resting on moderately consolidated materials are classified under this group. Not any of the soils of Palawan belong to this group.

PROFILE GROUP VII

Soils on upland areas developed on hard igneous bed rock having rolling to steep relief are under this group. Palawan soils in this group are as follows:

1. Tapul series;
2. Tagburos series;
3. Guimbalaon series;
4. Malalag series; and,
5. Coron series.

PROFILE GROUP VIII

Soils classified under this group are found on upland areas developed from consolidated sedimentary rock such as limestone, sandstone, and shale. The soils of Palawan within this group are:

1. Faraon series;
2. Sibul series; and,
3. Bolinao series.

The rocks from which the present materials of the majority of the soils of the province were derived are chert, gneiss, and quartzite. It was through the weathering of these rocks which

produced most of Palawan soils, except the limestone derived soils. Metamorphic rocks, like chert, gneiss, and quartzite, are very hard so that their disintegration is very slow. The soils thus produced are shallow. Furthermore, these rocks are very poor in mineral elements and consequently soils derived have very low fertility. All the series classified under soils of the plains came from this source.

The silica sand in del Pilar on the northern part of Puerto Princesa have an accumulation of weathered quartzite and chert. Most shore lines of Palawan are made up of silica sand. This sand analyzes 98 per cent silica. On many adjacent islands as well as on the mainland, some shores are likewise covered by white sand. This sand, however, are accumulation of triturated marine shells and are highly calcareous. This kind of sand as analyzed is 95 per cent calcium carbonate.

PRODUCTIVITY RATINGS OF PALAWAN SOILS

Soil productivity is the capacity of a certain soil type to produce a specified crop or a sequence of specified crops under a given set of management practices. A standard basis for rating productivity of soils is therefore adopted. It was determined by taking the approximate average yield of a given crop from extensively cultivated and better soil type of the Philippines wherein said crop is regularly grown and expressed in appropriate unit of production per hectare. The standard index, 100, is set for this average production per unit area. Crop yield from a specified soil type in any place or locality is then compared and expressed in terms of this standard index. The average yield per hectare of lowland rice was set at 60 cavans of palay per hectare; the corresponding standard index of which is 100. Therefore, a given soil type with a rating of 100 for lowland rice means this soil is as productive or as good as the standard. Likewise, a productivity rating of 50 for the soil type means that such soil for lowland rice can produce only one half as much as the standard, or an average of 30 cavans of palay per hectare. Soil types without ratings either means production data were not sufficient or the soil is considered not suitable to the crop.

Table 15 shows the comparative capacity of the different soil types in Palawan for certain crops relative to the standard

indexes or ratings for the Philippines. Careful note was taken of the agricultural practices observed in the locality to be in consonance with the specified set of management practices used in the setting up of the standard index. The standard management is without the use of fertilizers or soil amendments for this set of standard yields, index 100, listed below:

Upland rice	20 cavans of palay per hectare
Lowland rice	60 cavans of palay per hectare
Coconut	3,750 nuts per hectare
Corn	17 cavans per hectare
Tobacco	1,475 kg. per hectare

Before and during the time of the soil survey, most farming operations in Palawan was the *kaingin* method. Upland rice, corn, and root crops were cultivated in *kaingins* and only coconut and a few lowland rice were planted in regular cultivated fields.

TABLE 15.—*Productivity rating of Palawan soils for certain crops*

Soil type	Crop productivity index				
	Upland rice	Lowland rice	Coconut	Corn	Tobacco
Bay clay loam	-------	70	60	60	80
San Manuel clay loam	100	100	100	100	100
Aborlan loam	25	20	20	-------	-------
Busuanga loam	90	30	50	50	50
Dabuyan clay	100	30	50	50	70
Dabuyan silty clay loam	100	30	50	50	70
Brooke's clay	90	100	80	70	70
Brooke's clay loam	90	100	80	70	70
Quingua clay loam	100	80	100	100	70
Dalinao clay	50	-------	100	90	80
Sibul clay	50	-------	100	-------	-------
Faraon sandy clay	50	-------	100	-------	-------
Faron clay loam	25	-------	50	-------	-------
Tapul clay loam	50	-------	60	60	60
Tagburos clay	50	-------	60	60	60
Malalag clay	-------	-------	-------	-------	-------
Quimba'aon clay	50	50	70	50	60

LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDES FOR PALAWAN SOILS

Land capability classification determines what use the land is good for. Lands are of various kinds and each one is good for one purpose or another. Like equipment and machinery, land is capable of being used only for a certain operation. Likewise, when a load given to a piece of machinery is more than

it is capable of, break-down follows; so is land damaged when it is used for what it is not suitable.

We must use land according to what it is good for and treat it according to its requirements. The different soil types in Palawan are classified as to their capabilities and the corresponding necessary treatments for each class indicated.

In general, the different land capability classes recognized are as follows:

Class A is a very good land that can be safely cultivated extensively with ordinary farming practices.

Class B is good land that can be cultivated safely using easily applied conservation practices.

Class C is a moderately good land that can be used regularly for cultivated crops in good order of rotation but intensive conservation treatments should be observed.

Class D is a fairly good land that is best suited for pasture but can be cultivated to crops in good order of rotation provided intensive conservation measures are practiced.

Class L is land which is flat but is too wet or stony and is best suited for pasture or forestry.

Class M is land which is too steep, eroded, or shallow for cultivation. It is best suited for grazing or forestry if well managed.

Class N is land which is very steep, eroded, rough, shallow, or dry. It is preferably left to woodland but with very careful management it can also be for limited use as pasture.

Class X is land which is level but wet most of the time and cannot be economically drained. It can be utilized for farm ponds or recreation.

Class Y is land too steep, eroded, barren, and rugged. It should be reserved only for wildlife or recreation.

The factors used in land capability classification are: (1) the soil type, (2) slope of the land, and (3) the degree of soil erosion. These three factors taken as a whole will determine the capability class of any given land. The land capability class of a certain soil type will vary depending upon the slope and degree of erosion it may have.

The soils of the plains of Palawan do not exist in appreciable slopes nor are they badly eroded. These soils, therefore, are classified based solely from the soil type characteristics. On the other hand, upland soils exist under different groups of slopes and degrees of erosion. In order to be able to deter-

mine the capability classification of these soils the possible slope-erosion classes are considered together with the soil type characteristics. The possible slope-erosion classes and the corresponding capability class of each soil type are presented in table 16. Any soil type with a slope-erosion class other than the one listed in the table will be classified under the next lower capability class. Tagburos clay, for instance, with (b–1) slope-erosion class is listed as class Be. If in some other places Tagburos clay exists but with a (b–2) or (c–2) slope-erosion class, the capability class becomes Ce or De, respectively.

This table for the capability classification for each soil type of the province is presented in order to give the reader an idea of how to utilize the land.

TABLE 16.—*Land capability classes of Palawan soils*

Soil type No.	Soil type	Slope-erosion class	Capability class
[illegible]	Bay clay loam	a–0	Bw
[illegible]	San Manuel clay loam	a–0	A
[illegible]	Aborlan loam	a–0	Cs
[illegible]	Busuanga loam	a–0	Cs
[illegible]	Babuyan clay	a–0	Bw
[illegible]	Babuyan silty clay loam	a–0	Bw
[illegible]	Brooke's clay	a–0	Bw
[illegible]	Brooke's clay loam	a–0	Bw
[illegible]	Quingua clay loam	a–0	A
[illegible]	Bolinao clay	a–1	Be
[illegible]	Sibul clay	b–1	Ce
[illegible]	Faraon sandy clay	c–1	De
[illegible]		d–1	M
[illegible]	Tapul clay loam	a–1	Be
[illegible]	Tagburos clay	b–1	Be
[illegible]	Guimbalaon clay	c–1	Ce
[illegible]		d–1	De
[illegible]	Coron clay loam	a–1	Ce
[illegible]	Malalag clay	b–1	De
[illegible]		c–1	M
[illegible]	Hydrosol		X
[illegible]	Beach sand		Ds
[illegible]	Rough mountainous land		N

CLASS A

Soil Types: *San Manuel clay loam*
Quingua clay loam

Deep, level, well drained easily worked soil.

Class A land is nearly level. The soils are deep, dark, and usually fertile or can be made fertile under good management. They are usually deep alluvial soils which vary from silty to sandy and erosion is not a problem. They do not need drainage

or other special practices. The land rarely floods. It is easy to work and can be cultivated safely with ordinary good farming methods.

It is suited for intensive cropping. All crops common to the area can be grown on this land. Since soils of this class have good permeability, they are better adapted for crops other than rice. When used for lowland rice, puddling of the soil is usually necessary to prevent excess seepage.

Conservation farming requires such practices as liming (agricultural lime) when needed, the use of the correct kind and quantity of fertilizers and rotation of crops, which includes a legume or a soil improving crop for sustained production.

For better efficiency in the use of lime and fertilizers, the regular plowing under of any young green plants especially legumes or the application of any farm manure or compost material is advisable. Waterways through or adjacent to this class of land should be well vegetated with adapted grass, shrubs, or trees.

CLASS Be

Soil Types: *Bolinao clay*
Tapul clay loam
Tagburos clay

Good land that can be cultivated safely but needs certain erosion control measures in addition to good farm management practices to maintain productivity.

Class Be land is good from every standpoint but certain physical characteristics make it susceptible to moderate erosion damage since it usually occurs on smooth, gently sloping upland areas. The soils are deep but the subsoils are rather heavy. The slope is not more than 8 per cent and the soil is susceptible to moderate erosion when unprotected. This land, therefore, needs protection against erosion with control measures such as contour farming, terracing and strip cropping. Excess water must flow into safe or grassed channels. Diversion ditches should be constructed to prevent damage from runoff from any adjoining uplands.

All crops common to the area can be grown. Liming and fertilizing following recommended quantities and kinds should be done. You will need a good crop rotation that has a legume or soil improving crop such as mongo or soybean at least once

in 3 to 4 years. For all legumes, the soil should be well supplied with lime and phosphate-carrying fertilizer. The use of farm manure or compost is recommended. If the soil does not contain the right kind of bacteria inoculation should be done.

CLASS Bw

Soil Types: *Bay clay loam*
Babuyan clay
Babuyan silty clay loam
Brooke's clay
Brooke's clay loam

Land that can be cultivated safely but needs drainage in addition to good farm management practices to maintain productivity.

Class Bw is good land but because of poor drainage conditions some efforts to drain the excess water is needed. Included in this class are wet lands that can be easily drained. They usually occur on low bottoms near large streams. The soils are deep but the subsoils are heavy or the water table is very shallow and restrict water movement. Small ditches are needed to drain off surplus water. Diversion ditches should be constructed to prevent damage from runoff from adjoining uplands. Protection from occasional overflow may be needed.

When properly drained, corn, sugar cane, legumes, and many other row crops common in the area may be grown. Lowland rice is especially adapted.

Lime and fertilizers of the proper kinds and quantities, soil-improving crops, farm manure and compost are needed to maintain the productive capacity of this land class.

CLASS Ce

Soil Types: *Sibul clay*
Tagburos clay
Coron clay loam

Moderately good upland that can be cultivated safely if a carefully planned combination of conservation practices is applied.

Class Ce is moderately good land suitable for cultivation but needs the most careful use of the best soil conservation practices

to prevent erosion. Soils are good, deep to moderately deep, with slopes that would range from 8 to 15 per cent. It has moderate to severe erosion or is subject to moderate to severe erosion if unprotected.

To farm this land safely you will have to protect the land against erosion damage by installing a system of terraces, and supported by contour farming, and strip cropping. Terraces should empty into well grassed waterways or natural drainage.

After establishing the needed conservation measures, a good soil management program should be adapted. This will include a good crop rotation using a legume as a green manure crop, judicious use of lime and fertilizers, farm manure, and compost to build up the soil.

Many crops common in the area can be grown but they all should be planted on contours. Fruit trees should be planted on the contours and a leguminous cover crop should be maintained to protect the soil from erosion.

CLASS Cs

Soil Types: *Aborlan loam*
Busuanga loam

Moderately good land that can be cultivated to crops in a good rotation but needs intensive conservation treatment.

Class Cs land has soils that are moderately deep, and have very porous subsoils. The slopes usually range up to 15 per cent. It is too sandy for the proper retention of fertility and moisture. Moderate erosion is also a problem. It also includes areas of moderately good soil under low rainfall conditions.

For those soils that are sandy and deficient in organic matter the addition of animal manure, farm compost, or green manure is essential to keep up fertility as well as to increase the water holding capacity. Sloping lands may require some erosion control measures. Irrigation system will be needed for the low rainfall areas.

This kind of land is best suited to truck crops, orchard and some root crops. Lime, if required, and mineral fertilizers should be applied according to recommendations to maintain production.

CLASS De

Soil Types: *Faraon sandy clay*
Guimbalaon clay
Coron clay loam

Land good enough for occasional cultivation if handled with care but best suited to pasture and forest.

Class De land has slopes which run up to 25 per cent with moderate to severe erosion or is subject to moderate to severe erosion if left unprotected. The topsoil is generally thin with heavy, slowly permeable subsoil. It is fairly good land that can be cultivated occasionally with proper safeguards.

To farm the land a system of terraces has to be installed with properly laid out terrace outside in the absence of natural outlets if erosion damage or gullying has made the natural drainageways impracticable. Terrace outlets must be covered at all times with a thick vegetative growth, preferably grass. Reseed and fertilize if the grass is not well established.

Plowing as well as other farm operations must be done on the contour. Crop rotation on this class should be along the contours. Planting to row crops are not advisable. Close growing crops like grains or legume is preferable. This land when used for orchards, the trees should be planted on the contour and a good stand of leguminous cover crop should be maintained.

Where erosion on a moderately deep soil has not been so severe, gullies can be smoothened and then seeded either to grass or legumes. The soil thus scraped should be limed and fertilized to give a good start for the grass or legume. The legume seeds will need inoculation.

CLASS Ds

Soil Type: *Beach sand*

Land good enough for occasional cultivation if handled with care but best suited to pasture and forest.

Class Ds land is nearly level to sloping with deep soil but thin topsoil and light, very rapidly permeable subsoil with a low available moisture. Included in this class are level or nearly level lands with deep soils but because of climatic conditions not enough moisture is available for good crop growth. In such cases lands under this class need artificial irrigation.

This class of land is also subject to some degree of soil erosion during those sporadic period of heavy rainfall or after excess application of irrigation water.

This land is best suited if planted to vegetables or for truck farming. Root crops will do well too if planted at such time of the year when rainfall is abundant.

Increasing the organic matter content of the soil is recommended in order to increase the water holding capacity of the soil. This can be done by the application of animal manures.

It is not likely that this soil will need any lime but should it be desired, lime may be added only after an analysis of the soil is done. Fertilizers needed would be more of nitrogenous fertilizer for the leafy vegetables and ammonium phosphate or complete fertilizers as soil analysis may show for the fruiting vegetables.

CLASS M

Soil Types: *Faraon sandy clay*
Malalag clay

Land not suited for cultivation but good for grazing or forestry if handled with great care.

Class M land are usually on steep slopes up to 40 per cent. The soil is generally shallow or highly eroded making it not fitted for seasonal cultivation. Stones or gravels may be present or so numerous that they interfere with tillage operations. The land may be used for pasture or trees but needs to be carefully handled. In order to grow good legume or grass for pasture the land should be well prepared using lime and fertilizers as recommended in order to give the young plants a good start. You may need to build some diversion terraces around the heads of active gullies if any are present on the farm. Gullies that start to develop should be smoothened and sodded. Newly developed pastures should not be grazed severely. On well established pastures grazing should be well controlled and rotated. Wherever possible, stock ponds should be constructed to supply water to the animals.

Where climatic conditions permit, this land can be devoted to orchards for such crops as citrus, coffee, mango, or other similar crops but in all cases, the trees should be planted along the contours and good cover crops to protect the soil from washing should be provided.

As for forest, native trees should be protected from fires or *kaingins* and bare spaces planted to wood trees like *ipil-ipil*.

CLASS N

Soil Type: *Rough mountainous land*

Very steep land, eroded, rough, with shallow soils that can be used for grazing or for forestry if handled with great care.

This kind of land is not suitable for any tillage except that which is needed to establish permanent vegetations such as for permanent pasture land or woodland. This class consists of lands that are with slopes up to or more than 40 per cent. The land is rugged broken by many large gullies. The soil is badly eroded or very shallow. Stones may also be very abundant making it very impracticable to cultivate.

This land has very limited use. Where grass is growing, some grazing to cattle may be allowed but must be managed very carefully to prevent erosion. The pasture land will need very liberal fertilization and liming and reseeding.

Gullied lands are best used for trees and only trees growing well in the locality should be used. *Ipil-ipil* is specially recommended. Where trees are already growing, they should be left and protected from fire or *kaingin*.

CLASS X

Soil Type: *Hydrosol*

Land suited only for wildlife or recreation

Land of this class is usually level or is slightly depressed wherein water, either sea or fresh, stays most of the time making it impossible to utilize the land either for crops or pasture and trees. This land type is termed as hydrosol.

This land class may be used as site either for salt bed or for fish pond. Ordinarily this land is covered by mangroves or nipa palms or grasses as in the case of fresh water ponds. When the site is made for either fish ponds or salt beds the trees or palms may be disposed off, but good wide strip should be left along the outer borders of the shore line to protect the land from the scouring effect of the waves.

For fish ponds the site should be dug to not less than a meter in depth. To produce a good growth of algae which

is the feed for most fishes, the water in the pond should be fertilized.

SUMMARY

Palawan Province lies southwest of Manila in a NE–SW position. The provincial capital, Puerto Princesa, is the chief seaport, 363 nautical miles through the shortest navigable route from Manila. The fourth largest province in the Philippines (14,745.7 sq. km.), it includes the island of Palawan and about 200 smaller islands. Its population was 93,673 in 1938 and 107,244 in 1948. Long and narrow, a central chain of mountains run the length of Palawan Island, dividing it into two distinct parts and giving rise to short rivers and numerous streams.

The eastern side of Palawan Island from Babuyan in the north to Brooke's Point in the south has no pronounced rain period. It has a short dry season (Third Type of Climate). The rest of the island and the whole province has two pronounced seasons, six dry months and six rainy months (First Type of Climate). Typhoons rarely hit this province.

Geologic studies reveal that during the Pleistocene period, Mindoro, Palawan, and Borneo were one land mass. The present separation of Palawan from Borneo is established at very late Pleistocene; Mindoro first separating from Palawan before Palawan was separated from Borneo. Volcanic rocks are found in Palawan. According to McCaskey, volcanic activity had been incidental rather than as cause of the origin of this big land mass. Siliceous rocks and quartzites are found in the Calamianes Group and in the northern part of Palawan. Chert rocks dominate the mountainous western coast from Taytay to Alfonso XIII. From Alfonso XIII limestones extend south. Coron is wholly a limestone island. The geologic structure of Busuanga and Culion consists chiefly of cherts.

Palawan Island was formerly called "Paragua." The Calamianes Group and the northern portion of Paragua were colonized by Spain in the early part of the 18th century. The southern portion belonged to the Sultanate of Borneo but in the middle of the same century the Sultan ceded his territory to the Spaniards. At the close of the Spanish rule Paragua, Calamianes, and Balabac were three separate politico-military provinces. The civil government of the province was established on June 23, 1902; the present boundary was established in 1903; and in 1905 the name of province of Paragua was changed to province of Palawan.

The primary crops are rice, coconut, corn, and cassava. The secondary crops are sugar cane, native tobacco, coffee, pineapple, citrus, mongo, and banana.

In 1948 there were 12,010 reported farms in the province. Classified by tenure of farm operator, full owner operatorship was 91.76 per cent of the provincial total; part owner, 3.12 per cent; tenants of all kinds, 4.64 per cent; and, farm managers, 0.48 per cent. The area represented was 53,784.25 hectares, but only 22,258.38 hectares or 41.4 per cent was cultivated. Only 444 farms, 3.69 per cent of the total number, have areas of 20 hectares or more.

A great part of the provincial revenue is derived from fishing, lumbering, mining, and copra industry. Gathering of shells for button manufacturing, forest products, and edible bird's nests are some of the minor industries. High grade silica sand, abundant in Del Pilar, is shipped to Manila for bottle manufacturing.

Seventeen soil types and three miscellaneous land types were delineated in the survey and classification of the soils of the province. The soils were grouped into (1) Soils of the plains, (2) Soils of the uplands, and (3) Miscellaneous land types. An accompanying soil map shows the different soil and land types.

The most important soils of the plains classified in Palawan are soils of the San Manuel and Quingua series. Worked with conservation measures, because of their relative fertility, flat topography, and favorable tilth, these alluvial soils are good for agricultural purposes. San Manuel clay loam is found mostly along the southeastern coast of the province. Quingua clay loam is found south of Aborlan in the vicinity of the Malatgao River.

Soils of the uplands are divided into calcareous and non-calcareous groups. Bolinao clay, Sibul clay, and Faraon sandy clay are the calcareous upland soils or those developed in place of limestone. In the non-calcareous upland group, or soils developed from rocks other than limestone (andesite, basalt, quartz, chert, and gneiss), there are five soil series. Among these primary non-calcareous soils Guimbalaon and Tapul soils

are considered the best upland soils in the province. Guimbalaon clay is found only in Cuyo Island. Though this soil type may be acidic and low in available phosphorus and calcium, it is well drained, fairly friable, and deep. Tapul clay loam, as found in central, and some places in northeastern and southeastern Palawan, are deep and fairly fertile as indicated by the good stand of timber of very high commercial value and the first class variety of rattan called *sika*. The slopes of this series are not very steep, the soils are well drained externally and internally, and rock outcrops are absent thereby favoring mechanized farming.

The origin, generation, development, and the consequent structure of soils in the province are discussed. This study, genesis and morphology of soils, deals with the properties of soils due to the combined action of climate and living matter upon parent material as conditioned by relief through periods of time.

The capacity of a definite soil type to produce a specific crop or a series of specified crops under a given set of management practices is a part of this report. The productivity rating index of a particular soil is the ratio of the expected yield per hectare to the standard yield per hectare expressed in per cent.

Representative soil types in Palawan Province were chemically analyzed for available plant nutrients, acidity, and alkalinity. The relationship which exists between the absence or deficiency of different plant nutrients in the soil with the productive capacity of that soil for a specified crop or crops is explained.

The percentage of sand, silt, and clay for each soil type in the province was determined by laboratory mechanical analysis.

A glossary of common economic plants found in Palawan Province is included in the report.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN PALAWAN PROVINCE

Common name	*Scientific name*	*Family name*
Abaca	*Musa textilis* Nee	Musaceae
Akle	*Albizzia acle* (Blanco) Merr.	Leguminosae
Almaciga	*Agathis philippinensis* Warb.	Pinaceae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Amugis	*Lannea speciosa* Perk.	Anacardiaceae
Anibong	*Oncosperma tigilaria* (Jack.) Ridl.	Palmae
Apitong	*Dipterocarpus grandiflorus* Blanco	Dipterocarpaceae
Arrowroot	*Maranta arundinacea* Linn.	Marantaceae
Avocado	*Persea americana* Mill.	Lauraceae
Bakauan-lalaki	*Rhizophora candelaria* DG.	Rhizophoraceae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Banana	*Musa sapientum* Linn.	Musaceae
Bangkal	*Nauclea orientalis* Linn.	Rubiaceae
Betel nut	*Areca cathechu* Linn.	Palmae
Binunga	*Macaranga tanarius* (Linn.) Muell.–Arg.	Euphorbiaceae
Boho	*Schizostachyum lumanpao* (Blanco) Merr.	Gramineae
Bountiful bean	*Phaseolus vulgaris* Linn.	Leguminosae
Breadfruit	*Artocarpus communis* Forst.	Moraceae
Buri	*Corypha elata* Roxb.	Palmae
Cabbage	*Brassica oleracea* Linn. var. *capitata* Linn.	Cruciferae
Cacao	*Theobroma cacao* Linn.	Sterculiaceae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae
Calantas	*Toona calantas* Merr. and Rolfe	Meliaceae
Canistel	*Lucuma nervosa* A. DC.	Sapotaceae
Carambola	*Averrhoa carambola* Linn.	Oxalidaceae
Cashew	*Anacardium occidentale* Linn.	Anacardiaceae
Cassava	*Manihot esculenta* Crantz.	Euphorbiaceae
Chayote	*Sechium edule* Sw.	Cucurbitaceae
Chico	*Achras zapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Coffee	*Coffea arabica* Linn.	Rubiaceae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae
Corn	*Zea mays* Linn.	Gramineae
Cotton	*Gossypium brasiliense* Macf.	Malvaceae

Common name	Scientific name	Family name
Cucumber	*Cucumis sativus* Linn.	Cucurbitaceae
Custard apple	*Anona reticulata* Linn.	Anonaceae
Duhat	*Syzygium cumini* (Linn.) Skeels	Myrtaceae
Durian	*Durio zibethinus* Murr.	Bombacaceae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Gabi	*Colocasia esculenta* (Linn.) Schott	Araceae
Garlic	*Allium sativum* Linn.	Liliaceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
Guava	*Psidium guajava* Linn.	Myrtaceae
Guindaun	*Micromelum compressum* Merr.	Rutaceae
Iba	*Cicca acida* (Linn.) Merr.	Euphorbiaceae
Ipil	*Intsia bijuga* (Colebr.) O. Kuntze.	Leguminosae
Iron tree	*Xanthostemon verdugonianus* Naves	Myrtaceae
Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
Kalamansi	*Citrus microcarpa* Bunge	Rutaceae
Kamachile	*Pithecolobium dulce* (Roxb.) Benth.	Leguminosae
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Lantana	*Lantana camara* Linn.	Verbenaceae
Lemon	*Citrus limon* Burm.	Rutaceae
Lime	*Citrus aurantifolia* (Christm.) Swingle	Rutaceae
Lumbang	*Aleurites moluccana* (Linn.) Willd.	Euphorbiaceae
Mabolo	*Diospyros discolor* Willd.	Ebenaceae
Malugay	*Aporetica pinnata* DC.	Sapindaceae
Malungay	*Moringa oleifera* Lam.	Moringaceae
Mandarin	*Citrus nobilis* Lour.	Rutaceae
Mango	*Mangifera indica* Linn.	Anacardiaceae
Marang	*Artocarpus odoratissima* Blanco	Moraceae
Marango	*Azadirachta integrifoliola* Merr.	Meliaceae
Molave	*Vitex parviflora* Juss.	Verbenaceae
Mongo	*Phaseolus aureus* Roxb.	Leguminosae
Narra, white	*Pterocarpus blancoi* Merr.	Leguminosae
Nipa	*Nypa fruticans* Wurmb.	Palmae

Common name	Scientific name	Family name
Orange	*Citrus aurantium* Linn.	Rutaceae
Papaya	*Carica papaya* Linn.	Caricaceae
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceae
Paray-paray	*Oryza minuta* (Linn.) Presl. Muell.–Arg.	Gramineae
Para rubber	*Hevea brasiliensis* (HBK.)	Euphorbiaceae
Parina	*Kingiodendron alternifolium* (Elm.) Merr. & Rolfe	Leguminosae
Peanut	*Arachis hypogaea* Linn.	Leguminosae
Peas	*Pisum sativum* Linn.	Leguminosae
Pechay	*Brassica chinensis* Linn.	Cruciferae
Pepper	*Capsicum annuum* Lim.	Solanaceae
Pili	*Canarium luzonicum* (Blume) A. Pray	Burseraceae
Pineapple	*Ananas comosus* (Linn.) Mer.	Bromeliaceae
Pumelo	*Citrus maxima* (Burm.) Merr.	Rutaceae
Radish	*Raphanus sativus* Linn.	Cruciferae
Rice	*Oryza sativa* Linn.	Gramineae
Santol	*Sandoricum koetjape* (Burm. f.) Merr.	Meliaceae
Sika	*Calamus spinifolius* Becc.	Palmae
Sineguelas	*Spondias purpurea* Linn.	Anacardiaceae
Soursop	*Anona muricata* Linn.	Anonaceae
Soybean	*Glycine max* (Linn.) Merr.	Leguminosae
Squash	*Cucurbita maxima* Duchesne.	Cucurbitaceae
Sugar apple	*Anona squamosa* Linn.	Anonaceae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae
Sweet potato	*Ipomoea batatas* Linn.	Convolvulaceae
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Tamarind	*Tamarindus indica* Linn.	Leguminosae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* mill.	Solanaceae
Tugue	*Dioscorea esculenta* (Lour.) Burkill.	Dioscoreaceae
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceae
Urung	*Fagraea cochinchinensis* (Lour.) A. Chev.	Loganiaceae
Watermelon	*Citrullus vulgaris* Schrad.	Cucurbitaceae
Yakal	*Shorea gisok* Foxw.	Dipterocarpaceae

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PROVINCIAL GOVERNMENT OF PALAWAN
OFFICE OF THE PROVINCIAL BOARD
PUERTO PRINCESA

EXCERPT FROM THE MINUTES OF THE REGULAR MEETING OF THE PROVINCIAL BOARD OF PALAWAN, HELD AT PUERTO PRINCESA, PALAWAN, ON OCTOBER 30, 1948.

PRESENT:

Hon. Alfredo M. Abueg, Governor
Hon. Francisco Lagan, Board Member
Hon. Epifanio Dagomboy, Board Member

ABSENT:

None

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RESOLUTION No. 223

The letter of the Chief, Division of Soil Survey and Conservation, dated August 17, 1948, requesting for appropriation of ₱850.00 for the traveling expenses, including hire of guides, bancas and other conveyances of technical personnel to undertake the soil survey of Palawan, has been presented by the Secretary, and after mature deliberation;

On motion by Member Lagan,

RESOLVED, that the sum of ₱850.00 be and is hereby appropriated from the provincial general fund, not appropriated otherwise, for the traveling expenses, including hire of guides, bancas and other conveyances, of the survey party of the Division of Soil Survey and Conservation to undertake soil survey in Palawan.

RESOLVED, FURTHER, that the Provincial Treasurer be requested to prepare the necessary supplemental budget covering the amount appropriated herein.

Carried unanimously.

I hereby certify to the correctness of the above-quoted resolution.
(SEALED HERE)

(Sgd.) SILVERIO MANGA
Secretary, Provincial Board

EXCERPT FROM THE MINUTES OF THE REGULAR MEETING OF THE PROVINCIAL BOARD OF PALAWAN, HELD AT PUERTO PRINCESA, PALAWAN ON JULY 5, 1949.

PRESENT:

Hon. Alfredo M. Abueg, Governor
Hon. Epifanio Dagomboy, Board Member
Hon. Ildefonso Romantico, Board Member

ABSENT:

None.

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RESOLUTION No. 167

This Body has been informed by Mr. Alfredo Barrera, Soil Technologist, Division of Soil Survey and Conservation, Department of Agriculture and Natural Resources, assigned in Palawan, that his work of surveying the soil in Palawan is not yet completed, and that an amount of about ₱400.00 is needed to finish his work beginning July 1, 1949;

On motion by Governor Abueg,

RESOLVED, that, for the best interests of the province, the completion of the survey of the soil in Palawan, be and is hereby authorized.

RESOLVED FURTHER, that the sum of ₱400.00, be and is hereby appropriated from the General Fund, not otherwise appropriated, to permit the completion of said survey.

RESOLVED FINALLY, that certified copies hereof be furnished the provincial Treasurer and Mr. Alfredo Barrera, Chief of the Soil Survey Party in Palawan, for their information and guidance.

Carried unanimously.

I hereby certify to the correctness of the above-quoted resolution.

(Sgd.) SILVERIO MANGA
Secretary, Provincial Board

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