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5.0 DESCRIPTION OF THE BIOLOGICAL ENVIRONMENT

5.1 Introduction

5.1.1 Scope and Objectives

The Panama Canal Watershed, which corresponds to the Environmental Study Area (ESA) of the Panama Canal Expansion Project – Third Set of Locks-, is one of the country's most important watersheds because of the diversity of its uses. Among these uses are: the operation of the Panama Canal; the supply of water to several communities; energy production; industrial, tourism, livestock and agricultural, forest, and fishery activities. However, the value of this area is not only due to the economic or commercial benefits it provides, it is also due to the biological diversity of its flora and fauna resulting from all the physical conditions present in the area.

It is important to note that, because of the demographic growth and activities being carried out in the Watershed, the area's natural resources have been affected, a situation which threatens its ecological integrity. Among the detected threats are: deforestation, erosion, diminished soil fertility, sedimentation, and contamination of water bodies.

The Specific Study Area (SSA) encompasses a zone surrounding the Canal, Gatun Lake, and the maritime operation areas where the activities of the Project are concentrated, as well as where the historical and current activities related to the operations of the Canal are conducted. The Direct Impact Area (DIA), where the Project construction activities will take place, including the new locks, the approximation channels, dump sites, and contractor work areas, is located within the Specific Study Area (SSA).

This chapter contains information concerning the current state of the biological environment in the Specific Study Area (SSA) of the Panama Canal Expansion Project, which will serve as the basis to identify and assess the potential direct and indirect impacts of the Project.

5.1.2 Methodologies and Information Resources

There is a large number of scientific documents that reflect the numerous researches carried out regarding the flora and fauna in the Project's Specific Study Area (SSA) and the factors exerting pressure on the area, especially those carried out within the Panama Canal Watershed. Initially these studies reported on plant and animal collections and inventories, but they also gradually allowed an analysis of the existing types of habitats.

This document is also based on information pertaining to the flora and fauna included in the studies previously carried out for the Specific Study Area (SSA) of the Panama Canal Expansion Project – Third Set of Locks. It is worth noting that the technical studies, monitoring, and inventories used include intensive field studies as well as reviews of secondary sources, which made use of different methodologies and criteria to meet their objectives. A more detailed presentation of the sources utilized is given in each specific section developed to describe the biological environment.

5.2 Characterization of the Flora and Vegetation Cover

The flora of an area or region consists of a variety of plant species present in that given area. The flora of an area is grouped by forming vegetal associations specifically related to the distribution of the climate and type of soil. These vegetal associations are commonly denominated as the vegetation of the study area. The vegetation is characterized by having a peculiar physiognomy and flora; thus, vegetation categories can be differentiated on the basis of physiognomy: forest, shrub, grassland. This report presents the flora of the study area according to the type of vegetation to which it is associated.

The following ACP reports were used for information on the flora: ACP (2006 a-n); CEREB-UP (2005); Moffatt & Nichol / Golder 2005; URS Holdings (2004 a, b); Mora et al (2004); Louis Berger Group, Inc. (2004 a-d); Moffatt & Nichol / Golder 2004; Universidad de Panamá and ACP (2003); Consorcio Louis Berger, Universidad de Panamá and STRI (2002); ACP (2000); ANCON-TNC (1996 a, b); Mayo and Correa (1994); D'Croze et al, 1994; Amores et al, 1994; Duke et al. (1994); Marshall (1994); Croat (1978) and Glynn (1972).

5.2.1 Outline of the Flora of the Panama Canal Watershed

The climatic conditions in the entire area of the Panama Canal Watershed are appropriate for the growth of wooded vegetation. However, human intervention has introduced variations in the landscape, the reason why herbaceous vegetation and forest fragments can be found in different stages of growth. On the other hand, local soil conditions determine changes in the physiognomy and structure of the wooded vegetation.

Among efforts to classify the vegetation in Panama and in order to identify categories, the system proposed by UNESCO takes into consideration the physiognomic characteristics and ecological conditions. Because this system has been utilized in our country (ANAM, 2000a), reliable information on the Canal watershed is available. According to the UNESCO system, two natural categories of vegetation have been identified in the Project's specific study area (SSA): *tropical ombrophile evergreen, latifoliated lowland forest* and *tropical semicaducifolia lowland forest*. Different degrees of intervention and changes in the condition of the soil which determine vegetation variations can be observed in these categories.

The *tropical ombrophile evergreen, latifoliated lowland forest* lies north of the Gamboa townside and towards the Atlantic Coast. According to the sectoring of the project area, this type of vegetation is found in the: Atlantic Coast (1), Gatun Locks (2) and the northern – northeastern sector of Gatun Lake (3). The following natural variations are observed associated with this vegetation category (*tropical ombrophile marshy evergreen forest dominated by dicotyledons, mangrove forest, and dry-season deciduous tropical forest, latifoliated lowland forest*). Townsites are also observed (Colon City and Panama Canal installations) and *tropical ombrophile evergreen, latifoliated lowland forest – slightly intervened* (Margarita sector). In this natural category, several arboreal strata (at least three): canopy, subcanopy and understory. Canopy trees can reach up to 50 meters and a strata of trees representative of the canopy are found under the canopy. The understory is dense, with numerous shrubs and abundant brush.

The *tropical semicaducifolia lowland forest* is located from the Pacific Coast to Barro Colorado Island. This type of vegetation is found in the sectors of Gatun Lake (3), Culebra Cut (4), and the Pacific Coast (6). Like in the previous category, also present are vegetation variations introduced by human activities: *tropical semicaducifolia lowland forest – moderately intervened*, *tropical semicaducifolia lowland forest – slightly intervened*, *townsites*, *floodable savannas with low graminoid trees* and *production system with significant woody or spontaneous vegetation (10–50 %)*. Most canopy trees are caducifolious (+ 30 %), mixed with evergreen trees and shrubs.

According to the ACP (2006h), the Panama Canal Watershed covers a total of 339,650 hectares, of which 14% (46,543.040 hectares) are forests. It is important to note that 2,884.547 hectares (0.8% of the area) are covered with shrub, a cover that provides shelter and represents the transition to a secondary forest.

As a result of the update of CEREB-UP (2005) vegetation maps and the integration of existing information contained on the 2003 ACP watershed area vegetation maps, as well as 2004-2006 Landsat images, URS Holding Inc. GIS department presents Figure 5-1, showing the updated vegetation distribution in the watershed area, with 132,749.48 ha of forests, 46,969.69 ha of shrub and 77,724.42 of grassland , as well as 1,288.74 ha of bare soil. This information also shows that the best preserved vegetation is found on the east side of the watershed, where forests occupy 115,537.14 ha, while they only cover 17,212.34 ha on the west side.

The types of vegetation (see Section 5.2.2) present in the Project's Specific Study Area (SSA) and the Direct Impact Area (DIA) depend, just like in the General Study Area (GSA), on the condition of the soil and degree of human intervention. We can find different types of forests in this Zone, such as: intermediate secondary forests, mature secondary forests, mangrove forests and cativo forests. As shown in Table 5-1, the intermediate secondary forests, **shrub** are the types of vegetation found throughout the six (6) zones in which the Specific Study Area (SSA) has been divided.

Table 5-1

Acreeage (ha) by Category of Vegetation Cover in the Specific Study Area (SSA)

Zone	Bm	Bsm	Bsi	Bmg	C	M	P-H	Sd	U	A
1	0	0	8,676.14	507.56	813.67	260.36	1,207.38	32.46	1,427.71	22,208.50
2	0	0	188.79	0	0	17.34	81.33	0	14.91	3.87
3	844.42	1,150.51	16,839.62	0	0	825.25	322.76	25.61	161.72	34,132.99
4	260.77	1,168.60	7,880.76	0	0	452.52	515.09	98.27	139.22	29.98
5	0	957.22	3,612.75	0	0	491.95	719.90	51.41	804.85	161.47
6	0	0	2,700.40	39.30	0	486.76	1,080.04	0	3,018.78	28,190.85
Total	1,105.19	4,451.84	39,898.46	546.86	813.67	2534.18	3,926.50	207.75	5,567.19	84,727.66

Notes: in Forest column – Bm = mature forest, Bsm = mature secondary forest, Bsi = intermediate secondary forest, Bmg = mangrove forest, C= cativo forests, M = shrub P-H = grasslands, Sd= bare soil U= urban, A= water

Source: URS Holdings, Inc.

The climatic conditions present in the Project's Specific Study Area (SSA) favor forest growth. However, at present, it is easily observed that these have been altered by human activities, with their subsequent reduction to approximately 31% of the acreage of the total Specific Study Area (SSA).

Table 5-2 shows that the underbrushes and grasslands constitute the predominant vegetation in the Direct Impact Areas (DIA), occupying 2,078.72 ha, while the sum of the forests within this same area occupies 902.54 ha, equivalent to 28.2% of the land in the Direct Impact Area (DIA).

Table 5-2

Acreeage (ha) by Category of Vegetation Cover in the Direct Impact Area (DIA)

Zone	Bm	Bsm	Bsi	Bmg	C	M	P-H	Sd	U	A
1	0	0	75.98	0	0	50.82	122.26	0.98	1.58	325.25
2	0	0	190.29	0	0	7.52	242.22	3.92	28.12	123.51
3	0	4.11	0	0	0	0.85	4.28	1.64	1.31	3,911.14
4	0	7.73	159.40	0	0	86.81	524.26	50.04	26.24	219.18
5	0	15.18	250.66	13.30	0	93.38	712.69	0.22	51.58	199.59
6	0	0	161.05	24.84	0	110.97	122.66	0	55.87	4,092.18
Total	0	27.02	837.38	38.14	0	350.35	1,728.37	56.80	164.70	8,870.85

Notes: in Forest column – Bm = mature forest, Bsm = secondary mature forest, Bsi = secondary intermediate forest, Bmg = mangrove forest, C= cativo forests, M = shrub, P-H = grasslands, Sd = bare soil U= urban, A= water

Source: URS Holdings, Inc.

As regards to the flora, the Canal Watershed Monitoring Project presents a record of 1,125 plant species in its observation plots (STRI-USAID-ANAM, 1999). Most of the plant species present in the Panama Canal Watershed correspond to species typical of the lowlands and of ample distribution in the country. Some of these species present in the Panama Canal Watershed have a neotropical distribution pattern, and others are related to the flora in the Chocó region. However, there are some tropical highland species present in the summits of Trinidad Hill and the ridge that joins El Valle de Antón with Campana Hill, Jefe Hill, and the mountain ridge delimiting the northern and northeastern areas of the watershed, as indicated in ANCON (1995).

5.2.2 Classification of the Vegetation of the General Study Area (GSA), Specific Study Area (SSA), and Direct Impact Area (DIA)

As previously mentioned, the vegetation in the study area is varied, with some fragments in their natural state, while others are the result of human intervention. Following are some characteristics that define the different types of vegetation within the Project’s Environmental Study Area (ESA).

5.2.2.1 Forests

A forest is considered to be a group or association of trees in a specific area, in conjunction with countless natural elements (minerals, water, vegetation, bacterias, fungi, and animals) form

complex ecosystems. The diversity of climatic conditions, soil, and degree of human intervention determine the presence of different types of forests; which possess different types of physiognomy and associated plant species. Present in the study area are mature forests (evergreen or perennifolious, semicaducifolius and wetlands) and secondary forests in different stages of growth.

Mature Forest

In this type of vegetation the landscape is dominated by trees, remnants of vegetation present previous to the construction of the Canal or established in the area shortly after the construction of the Canal. In the mature forest, the canopy reaches an average height in excess of 30 meters. In this type of forest at least three arboreal strata can be differentiated. In addition, a strata comprised of a mix of shrub and herbaceous species can be observed in the forest floor. Also observed in the studied area are mature evergreen or perennifolious forests, semicaducifolious forests, mangroves and cativo forests, among others.

Mature Secondary Forest

The physiognomy and tree species associated with the secondary forest vary according to its stage of growth. The secondary forest represents vegetation that has been established as a result of plant sucession in areas that have been slashed or perturbed. Secondary forests associated to evergreen or perennifolius and semicaducifolius forests are observed in the area of study. In the mature secondary forests, the canopy reaches heights between 26 and 28 meters, with emergent trees stretching up to 35 meters above the forest floor. Although this type of forest presents some tree species typical of mature forests, the elements typical of a secondary forest are still dominant.

Intermediate Secondary Forest

The intermediate secondary forest is the forest cover with the highest distribution within the Specific Study Area (SSA). The intermediate secondary forest presents a cover dominated by trees reaching a height of up to 25 meters and grown on slashed or perturbed soil, which are less than a 100 years old. They are dominated by pioneer species and present few mature individuals of the species found in mature forests. Two tree strata can be observed in these secondary

forests, as well as a larger number of tree species older than 30 years of age than those found in younger forests.

Cativo Forest

This type of vegetation is characterized by developing in seasonally flooded freshwater wetlands and commonly found in alluvial planes. The dominant tree species is the cativo (*Prioria copaifera*), a leguminous tree adapted to seasonally flooded environments. These ecosystems are of ecological interest because they provide abundant food and shelter for many species of native as well as migratory fauna.

Mangrove Forest or Mangrove

Mangroves are forests made up of salt-tolerant woody plants, characterized by their common ability to grow and prosper along protected coastal areas, and occupy saline sediments, frequently anaerobic. Mangroves are dominated by a group of tree species that have developed physiological, reproductive, and structural adaptations that allow them to colonize unstable substrate and flooded areas, subject to the tidal changes on the tropical and subtropical coasts protected from breaking waves (estuaries). Among the dominant species are: the red mangrove or *Rhizophora mangle*, the white mangrove or *Laguncularia racemosa*, the black mangrove or *Avicennia bicolor*, *Avicennia germinans*, and *Conocarpus erectus*.

5.2.2.2 Shrub

Shrub are vegetal communities dominated by high shrubs (1.5 to 5 meters), usually well branched at the base, mixed with young trees and herbaceous plants. The underbrush is a transitory vegetation that comes after the grass vegetation and gives way to a tree vegetation after 10 to 20 years, depending on the characteristic uses given to the site.

5.2.2.3 Grassland

In this type of vegetation, the landscape is dominated by herbaceous species, with some shrubs and scattered trees. In the study area, this ecosystem is artificial, since its development has been influenced by human activity. Some species have been introduced, such as the wild sugarcane (*Sacharum spontaneum*), while others are natives to the area.

5.2.3 Vegetation Cover and Characterization of the Flora in the Specific Study Area (SSA) and Direct Impact Area (DIA) by Zone

5.2.3.1 Atlantic Coast (Zone 1)

This Zone is located in the north sector of the canal zone and includes the coast and adjacent land on both sides of the Canal entrance (Figure 5-4). The climatic characteristics of this Zone are appropriate for the development of a forest cover dominated by tropical ombrophile evergreen, latifoliated lowland forest, since it is located in the life zone of a tropical wet forest (Tosi, 1971). With these climatic conditions, it is expected that the forest landscape be dominated by trees over 35 meters high (canopy) and various tree strata (Photo 5-1). However, at present, different types of vegetation are observed in the Specific Study Area (SSA); the intermediate secondary forest covers an area of 8,676.14 ha; the underbrush covers 260.36 ha; and the grassland covers 1,207.38 ha. The mangrove and cativo forests, which in the Atlantic Coast are only present within the Specific Study Area (SSA), are distributed as follows: 507.56 ha of mangrove and 813.67 ha of cativo.

With regards to the Direct Impact Area (DIA) (Table 5-3), the natural vegetation has been altered, and the landscape is dominated by 122.26 ha of grassland, 75.98 ha of intermediate secondary forest, and 50.82 ha of shrub. Of the total secondary forests existing in this Zone, only 0.74% (75.98 ha) lies within the Specific Study Area (SSA).

Table 5-3**Acreeage (ha) by Category of Vegetation Cover in the Atlantic Coast (Zone 1)**

Zone	Bm	Bsm	Bsi	Bmg	C	M	P-H	Sd	U	A
SSA	0	0	8,676.14	507.56	813.67	260.36	1,207.38	32.46	1,427.71	22,208.50
DIA	0	0	75.98	0	0	50.82	122.26	0.98	1.58	325.25
Total	0	0	8,752.12	507.56	813.67	311.18	1,329.64	33.44	1,429.29	22,533.75

Notes: in the Forest column – Bm = mature forest, Bsm = secondary mature forest, Bsi = intermediate secondary forest, Bmg = mangrove forest, C= cativo forests, M = shrub, P-H = grasslands, Sd = bare soil, U = urban, A = water

Source: URS Holdings, Inc.

According to the reports consulted, 413 species distributed among eighty-five (85) families (Table 5-4) were collected in this sector. The best represented group, because of the diversity of families, and species, is the Magnoliopsida (dicotyledons), followed by the Liliopsida (monocotyledons). The conifer group is represented by one family (Zamiaceae). In the Magnoliopsida group, the best represented families are: Fabaceae (Leguminous) with thirty-four (34), Rubiaceae with thirty-two (32), Moraceae with nineteen (19) and Sapindaceae with eighteen (18). These figures agree with the expectations for lowland forests, where the best represented families are Fabaceae and Rubiaceae. In the Liliopsida group, the best represented families are Araceae with twenty-seven (27) species, Orchidaceae with fifteen (15), and Arecaceae with ten (10).

Table 5-4**Number of Flora Species and Families by Group Within Zone 1**

Group	Families	Species
Liliopsida	14	74
Magnoliopsida	66	327
Gimnosperma	1	3
Ferns and Allies	4	9
Total		413

Source: Fundación Universidad de Panamá (FUDEP).

The diversity of climatic conditions, soil, and human influence observed in this Zone determine the diversity of vegetation and species. The most common species by type of vegetation are: for the intermediate secondary forest, tree species such as: *Anacardium excelsum*, *Apeiba*

membranacea, *Guarea grandifolia*, *Luehea semannii*, *Sapium caudatum*, *Virola surinamensis*, *Trichilia tuberculata*, *Hura crepitans*, *Spondias mombin*, *Cavanillesia platanifolia*, *Pseudobombax septenatum*, *Cordia alliodora* and *Calycophyllum candidissimum*, and *Pachira quinata*. Among the species representative of the mangrove forest are: *Rhizophora mangle*, *Avecennia bicolor*, and *Laguncularia racemosa*. In addition, there is also a cativo forest, which is limited to the Specific Study Area (SSA), and which is characterized by *Prioria copaifera*

Other types of forest in the Specific Study area (AEE) of the Atlantic coast include the dry-season deciduous, latifoliated lowland forest in the western coast of Limon Bay, and a patch of ombrophile marshy evergreen tropical forest dominated by dicotyledons between Limon Bay and the lower Chagres River.

Underbrushes are highly intervened forest areas with numerous plant species, such as: *Spondias mombin*, *Anacardium excelsum*, *Ficus insipida*, *Luehea seemannii* and *Cinnamomum triplinerve*, *Conostegia xalapensis*, *Myriocarpa longipes* and *Piper* sp., among others. Herbaceous species observed include: *Costus villosissimus*, *Echinochloa colona*, *Eleocharis* sp., *Fimbristylis dichotoma* and *Kyllinga pumila*.

The more transformed zones are dominated by grasslands which include species such as: *Panicum purpurascens*, *Eleocharis fistulosa*, *Saccharum spontaneum* and *Gynerium sagittatum*. Among the trees associated with these grasslands are: *Cecropia peltata*, *Anacardium occidentale*, *Psidium guajava* and *Erythrina fusca*.

5.2.3.2 Gatun Locks (Zone 2)

The natural vegetation of this Zone corresponds to an ombrophile evergreen, latifoliated lowland tropical forest. Since the present locks and installations related to their operation are located in this Zone, the landscape is dominated by grasslands in the western sector and by secondary forest in the eastern sector (Figure 5-2). In the Specific Study Area (SSA), the intermediate secondary forests covers 188.79 ha, the shrub covers 17.34 ha, and grasslands cover 81.33 ha. (Photo 5-2)

Table 5-5 shows that the dominant vegetation in the Direct Impact Area (DIA) in Zone 2 is grassland, covering 236.83 ha, followed by 190.18 ha of secondary forests and 7.52 ha of shrub. These data indicates that this Zone is highly intervened.

Table 5-5
Acreeage (ha) by Category of Vegetation Cover in Gatun Locks (Zone 2)

Zone 2	Bm	Bsm	Bsi	Bmg	C	M	P-H	Sd	U	A
AEE	0	0	188.79	0	0	17.34	81.33	0	14.91	3.87
AID	0	0	190.29	0	0	7.52	242.22	3.92	28.12	123.51
Total	0	0	379.08	0	0	24.86	323.55	3.92	43.03	127.38

Notes: in the Forest column – Bm = mature forest, Bsm = secondary mature forest, Bsi = intermediate secondary forest, Bmg = mangrove forests, C= cativo forests, M = shrub, P-H = grasslandes, Sd = bare soil, U = urban, A = water

Source: URS Holdings, Inc.

According to reports consulted, there is a total of 460 species distributed among ninety-four (94) families in this sector (Table 5-6). The Magnoliopsida group presents the greatest species diversity (363), followed by the Liliopsida (80), and by ferns and allies with seventeen (17) species. As expected for the tropical region, the best represented families of the Magnoliopsida group are Rubiaceae and Fabaceae (both with 39 species). Other families of this group with diversity of significant species are the Sapindaceae with nineteen (19), the Moraceae and the Flacourtiaceae with seventeen (17), and the Euphorbiaceae with fifteen (15) species. The best represented family of the Liliopsida group is the Araceae with twenty-six (26) species; followed by the Areaceae and Poaceae with eight (8) species each.

Table 5- 6
Number of Flora Species and Families by Group Within Zone 2

Group	Family	Species
Liliopsida	14	80
Magnoliopsida	74	363
Gymnospermas	0	0
Ferns and Allies	6	17
Total	94	460

Source: Fundación Universidad de Panamá (FUDEP).

As far as forests are concerned, this Zone only presents intermediate secondary forests and fragments of wet forests, which correspond to an ombrophile evergreen, latifoliated lowland tropical forest. The most common species include: *Anacardium excelsum*, *Hura crepitans*, *Luehea seemannii*, *Pseudobombax septenatum*, *Spondias mombin*, *Virola sebifera* and *Ficus insipida*.

The shrub in Zone 2 represents highly intervened areas of ombrophile evergreen, latifoliated lowland tropical forest, where the following elements are observed: *Spondias mombin*, *Anacardium excelsum*, *Casearia guianensis*, *Ficus insipida*, *Luehea seemannii*, *Cocos nucifera* and *Cinnamomum triplinerve*. The shrub species include *Conostegia xalapensis*, *Myriocarpa longipes*, *Piper* sp. and *Cyathea multiflora*. Among the herbaceous species, the following are observed: *Costus villosissimus*, *Echinochloa colona*, *Eleocharis* sp., *Fimbristylis dichotoma*, *Heliconia marie* and *Kyllinga punila*. Some of the most common vine are: *Cissus sicyoides*, *Lantana camara*, *Davilla kunthii*, *Gouania polygama* and *Passiflora biflora*.

The most altered areas are induced savannas or grasslands with sparse trees such as *Byrsonima crassifolia*, *Casearia arborea*, *Cinnamomum triplinerve*, *Cochlospermum vitifolium*, *Dendropanax arboreus*, *Gliricidia sepium*, *Guazuma ulmifolia*, *Miconia argentea*, *Muntingia calabura*, *Ochroma pyramidale*, *Pseudobombax septenatum*, and *Psidium guajava*. Among the shrub species, shrubs of the genus *Piper* can be observed. Among the vine, the following are observed: *Cissus sicyoides*, *Lantana camara*, *Melothria trilobata*, and *Tetracera volubilis*, among others. Herbaceous species include: *Cuphea carthagenensis*, *Cyperus luzulae*, *Cyperus odoratus*, *Flemingia strobilifera*, *Heliconia latispatha*, *Ischaemum timorense*, *Mimosa pudica*, *Momordica charantia*, and *Panicum maximum*.

5.2.3.3 Gatun Lake (Zone 3)

Within the Specific Study Area (SSA) this Zone covers 34,132.99 ha of water (Figure 5-2). The greatest representation of forests within the Specific Study Area (SSA) is found in this Zone, 18,834.54 ha. The natural vegetation of the Gatun Lake zone includes the transition between the ombrophile evergreen, latifoliated lowland forest (to the North) and the tropical semideciduous

lowland forest (to the South). However, the vegetation in a large part of the area has been replaced by shrub (825.25 ha) and grassland (322.76 ha), which correspond to productive systems with significant natural woody or spontaneous vegetation.

Species of aquatic plants are observed in the banks of Gatun Lake, in protected sectors, and at the mouth of rivers and streams. Floating, submerged, and emergent species are observed in this type of vegetation. Among the species of aquatic weeds, the following can be observed: *Hydrilla verticillata*, *Nymphaea ampla*, *Pontederia rotundifolia*, *Salvinia radula*, *Ludwigia leptocarpa*, and *Typha domingensis*. (Photo 5-3)

Water is predominant in the Direct Impact Area (DIA) (3,911.14 ha), as indicated in Table 5-7. Secondary forests occupy only 4 ha, and represent a minimum portion of this Zone (0.02%), while shrub occupy 0.8 ha, and grasslands occupy 4.78 ha.

Table 5-7
Acreeage (ha) by Category of Vegetation Cover (Zona 3)

Zone 3	Bm	Bsm	Bsi	Bmg	C	M	P-H	Sd	U	A
AEE	844.42	1,150.51	16,839.62	0	0	825.25	322.76	25.61	161.72	34,132.99
AID	0	4.11	0	0	0	0.85	4.28	1.64	1.31	3,911.14
Total	844.42	1154.62	16,839.62	0	0	826.10	327.04	27.25	163.03	38,044.13

Notes: in the Forest column – Bm = mature forest, Bsm = secondary mature forest, Bsi = intermediate secondary forest, Bmg = mangrove forest, C= cativo forests, M = shrub, P-H = grassland, Sd = bare ground, U = urban, A = water

Source: URS Holdings, Inc.

Reports pertaining to the flora in this Sector lists 420 species, distributed among 96 families (Table 5-8). Magnoliopsida is the best represented group with 329 species, followed by Liliopsida with 74 species. In the Magnoliopsida group, the best represented families are Fabaceae with 34 species and Rubiaceae with 33 species. Other species well represented are: Melastomataceae (17), Asteraceae (14) and Euphorbiaceae (13). In the Liliopsida group, the best represented families are: Poaceae with 29 species, Arecaceae with 13, and Araceae with 7 species.

Table 5- 8

Number of Flora Species and Families by Group Within Zone 3

Grupo	Familia	Especies
Liliopsida	16	74
Magnoliopsida	71	329
Gymnospermas	1	1
Ferns and Allies	8	16
Total	96	420

Note: Barro Colorado Island records, which total 1,324 species, are not included.
Source: Fundación Universidad de Panamá (FUDEP).

The types of vegetation present in this Zone consist of mature forests and secondary and intermediate secondary forests, with the following tree species: *Alseis blackiana*, *Anacardium excelsum*, *Andira inermis*, *Casearia arborea*, *Apeiba membranaceae*, *Astronium graveolens*, *Dipteryx panamensis*, *Trattinnickia aspera* and *Hura crepitans*. In the secondary forests, the following are observed: *Pachira quinata*, *Pachira sessilis*, *Byrsonima spicata*, *Vochysia ferruginea*, *Casearia guianensis* and *Schefflera morototoni*.

Other type of induced vegetation in this Zone is the herbaceous vegetation (grasslands) which include the following species: *Hyparrhenia rufa*, *Saccharum spontaneum*, *Rottboellia cochinchinensis*, *Sorghum halapense*, *Alysicarpus vaginalis*, *Spigelia anthelmia* and *Waltheria indica*. Floating, submersed, and emergent aquatic plant species are observed at the banks of Gatun Lake, in protected sectors, and at the mouth of rivers and streams. Among the species of aquatic weed, the following can be observed: *Hydrilla verticillata*, *Nymphaea ampla*, *Pontederia rotundifolia*, *Salvinia radula*, *Ludwigia leptocarpa* and *Typha domingensis* among others. (Photo 5-3)

5.2.3.4 Culebra Cut (Zone 4)

This Zone consists of a narrow strip of land on both sides of Culebra Cut. Because it is utilized in the operations of the Canal, it is under the constant influence of human activities (Figure 5-3). As a result, this landscape undergoes constant change, presenting herbaceous vegetation and fragments of semideciduous tropical lowland forests. Within the specific study area (AEE) in

the Culebra Cut zone, forests occupy 9,310.13 ha. In the areas where the forest has been replaced by productive systems with significant natural woody or spontaneous vegetation, there are 452.52 ha of shrub and 515.09 ha of grassland (Photo 5-4).

The area of direct impact (AID) is dominated by productive systems with significant natural woody or spontaneous vegetation that include 524.26 ha of grassland and 86.81 ha of shrub. Within the area of direct impact (AID) in the Culebra Cut zone, 7.73 ha of mature secondary forest and 159.40 ha of intermediate secondary forest remain, representing 1.8% of the existing forest in the Zone. Table 5-9 clearly shows the intervention in the area of direct impact (AID) of the zone corresponding to Culebra Cut.

Table 5-9

Acreeage (ha) according to Vegetal Coverage in Culebra Cut (Zone 4)

Zone 4	Bm	Bsm	Bsi	Bmg	C	M	P-H	Sd	U	A
AEE	260.77	1,168.60	7,880.76	0	0	452.52	515.09	98.27	139.22	29.98
AID	0	7.73	159.40	0	0	86.81	524.26	50.04	26.24	219.18
Total	260.77	1,176.33	8,040.16	0	0	539.33	1,039.35	148.31	165.46	249.16

Notes: in Forest column – Bm = mature forest, Bsm = mature secondary forest, Bsi = intermediate secondary forest, Bmg = mangrove forest, C= cativo forests, M =shrub, P-H = grasslands, Sd = bare ground U = urban, A = water

Source: URS Holdings, Inc.

Recorded in this sector were 150 species distributed in 35 families (Table 5-10). The best represented groups are Liliopsida with 91 species, followed by Magnoliopsida with 56 species. The abundance of families of the Liliopsida class, more than of the Magnoliopsida class, is noticeable. It is interesting to note that in the Gymnospermas, one very primitive species (*Gnetum leyboldii*) is recorded, sole representative of the Gnetaceae family in Panama. In the Magnoliopsida class, the best represented families are: gesneriaceae with 9 species and Fabaceae with 8. The Orchidaceae, with 89 species, is the best represented family in the Liliopsida class.

Table 5- 10

Number of Species and Families of Flora by Group within Zone 4

Group	Family	Species
Liliopsida	4	91
Magnoliopsida	29	56
Gymnospermas	1	1
Ferns and Allies	1	2
Total	35	150

Source: Fundación Universidad de Panamá (FUDEP).

The mature forests, secondary mature forests, and secondary intermediate forests in the Culebra Cut zone are of the lowland semi-deciduous of tropical forests, and have numerous lowland deciduous species. Tree species and palms that occur more frequently include: *Cinnamomum triplinerve*, *Spondias mombin*, *Ficus insipida*, *Cordia alliodora* y *Bursera simaruba*. Moreover, although less frequent, also found: *Terminalia amazonia*, *Luehea seemannii*, *Attalea butyracea*, *Anacardium excelsum*, *Dalbergia retusa*, *Cecropia peltata*, *Pittoniotis trichantha* y *Annona purpurea*.

The shrub species most commonly observed are: *Hirtella racemosa*, *Doliocarpus olivaceus* and *Manihot aesculifolia*. Some of the most common trees are: *Elaeis oleifera*, *Spondias purpurea*, *Annona reticulata*, *Annona spraguei* (endemic), *Stemmadenia grandiflora*, *Cordia panamensis* and *Lennea viridiflora*. The following herbaceous species are observed: *Lycoseris triplinervia*, *Dichorisandra hexandra*, *Costus villosissimus*, *Cyperus chorisanthos*, *Cyperus rotundus*, *Calathea latifolia*, *Chusquea simpliciflora*, *Panicum maximum*, *Asclepias curassavica* and *Flemingia strobilifera*.

The dominant grasses observed especially in the areas adjacent to Canal installations are *Hyparrhenia rufa* and *Saccharum spontaneum*. Occasionally, the following tree species can be observed among the grasses: *Pittoniotis trichantha*, *Cordia alliodora*, *Andira inermis*, *Xylopia frutescens* and *Apeiba membranacea*, among others.

5.2.3.5 Pacific Locks (Zone 5)

The specific study area (AEE) corresponding to the Pacific Locks (Zone 5), includes 4,569.97 ha of mature secondary and intermediate secondary forest of the semideciduous tropical lowland type and 1,211.85 ha of productive systems with significant natural woody or spontaneous vegetation that includes 491.95 ha of shrub and 719.90 ha of grassland. Even though the climatic conditions in the study area are homogeneous, the historic use of the land and the soil characteristics (type of soil and humidity) introduce variations in the present vegetation. (Photo 5-5)

The zone of the Pacific Locks (Figure 5-3), historically has been a highly perturbed Zone, a condition clearly established in Table 5-11, which shows the distribution according to the type of vegetation in the area of direct impact (AID). Of the 4,835.81 ha of forests in zone 5, only 265.84 ha will be affected, corresponding to 19.89% of the total forests existing in this Zone. Most of the area that will be affected is occupied by grassland (712.69 ha) and by shrub (93.38 ha). Soil without vegetation occupies 0.22 ha.

Table 5-11

Acreeage (ha) by Vegetation cover in the Pacific Locks, Zone 5

Zone 5	Bm	Bsm	Bsi	Bmg	C	M	P-H	Sd	U	A
AEE	0	957.22	3,612.75	0	0	491.95	719.90	51.41	804.85	161.47
AID	0	15.18	250.66	13.30	0	93.38	712.69	0.22	51.58	199.59
Total	0	972.40	3,863.41	13.30	0	585.33	1,432.59	51.63	856.43	361.06

Notes: in the Forest column – Bm = mature forest, Bsm = mature secondary forest, Bsi = intermediate secondary forest, Bmg = mangrove forest, C= cativo forest, M = shrub, P-H = grasslands, Sd = bare ground, U = urban, A = water

Source: URS Holdings, Inc.

In this Sector, 197 species distributed among 68 families (Table 5-12) have been recorded. The Magnoliopsida is the best represented group with 162 species distributed among 51 families. In order of importance, it is followed by the Liliopsida group with 29 species distributed among 12 families. The best represented families in the Magnoliopsida group are: Rubiaceae with 16

species and Fabaceae with 15 species. The best represented families in the Liliopsida group are: Poaceae with 8 species and Cyperaceae with 8 species.

Table 5- 12
Number of Flora Species and Families by Group in Zone 5

Group	Family	Species
Liliopsida	12	29
Magnoliopsida	51	162
Gymnosperma	0	0
Ferns and Allies	5	6
Total	68	197

Source: Fundación Universidad de Panamá (FUDEP).

The secondary and mature semideciduous tropical lowland forests in the zone of the Pacific Locks present the following species: *Spondias mombin*, *Enterolobium cyclocarpum*, *Cordia alliodora*, *Cassia moschata*, *Anacardium excelsum*, *Pseudobombax septenatum*, *Attalea butyracea*, *Astronium graveolens*, *Pittoniotis trichantha*, *Luehea seemannii*, *Guazuma ulmifolia* and *Cupania rufescens*. The representative species of secondary growth are: *Zanthoxylum panamense*, *Guazuma ulmifolia*, *Cojoba rufescens*, *Luehea speciosa*, *Annona purpurea*, *Cinnamomum triplinerve*, *Enterolobium cyclocarpum*, *Ceiba pentandra* and *Pseudobombax septenatum*.

The canopy of the mangrove forest is dominated by the species *Avicennia germinans* (black mangrove) and *Laguncularia racemosa* (white mangrove). A strata formed by *Pelliciera rhizophorae* (tea mangrove) and *Rhizophora mangle* (red mangrove) can be observed underneath the canopy of the mangrove forest. The fern *Acrostichum aureum* (golden leather fern) is frequently observed in this type of vegetation. The most common herbaceous species are: *Malachra alceifolia*, *Waltheria indica* and *Lantana camara*. Also common are vine, lianas, and climbers such as: *Phryganocydia phellosperma*, *Combretum decandrum*, *Ipomoea quamoclit*, *Ipomoea trifida*, *Mucuna pruriens* and *Cissus erosa*.

The shrubs is dominated by species such as *Hirtella racemosa*, *Dolioscarpus olivaceus* and *Manihot SSaculifolia* and young tres of species such as *Elaeis oleifera*, *Spondias purpurea*,

Annona reticulata, *Annona spraguei* (endemic to the country), *Stemmadenia grandiflora*, *Cordia panamensis* and *Lennea viridiflora* entre otras. Among the herbaceous species the following are observed: *Lycoseris triplinervia*, *Dichorisandra hexandra*, *Costus villosissimus*, *Cyperus chorisanthos*, *Cyperus rotundus*, *Calathea latifolia*, *Chusquea simpliciflora*, *Panicum maximum*, *Asclepias curassavica* and *Flemingia strobilifera*. Some of the most common vine are: *Monstera deliciosa*, *Dioscorea mexicana*, *Dioscorea urophylla*, *Mucuna pruriens* and *Strychnos panamensis*.

Wild sugarcane (*Saccharum spontaneum*) usually predominates in the shrublands, completely covering the soil and not allowing the sunlight to penetrate. This type of sugarcane is the only one that grows in these cases and does not allow other species to become established. When there is very little development of shrubs and the sunlight is allowed to penetrate to the soil, then the presence of certain tree species, such as: *Tecoma stans*, *Cordia alliodora*, *Bursera simaruba*, *Cecropia peltata*, *Cochlospermum vitifolium* and *Guazuma ulmifolia*, among others, is observed. Among the shrub species observed is the *Hamelia patens*. Among the vine capable of climbing over the wild sugarcane the following are observed: *Ipomoea quamoclit*, *Bonamia trichantha*, *Merremia umbellata*, *Melothria pendula* and *Melothria trilobata*, among others. The following herbaceous species, in addition to the wild sugarcane, are observed: *Rottboellia cochinchinensis*, *Sorghum halapense*, *Alysicarpus vaginalis*, *Spigelia anthelmia* and *Waltheria indica*.

5.2.3.6 Pacific Coast (Zone 6)

The Pacific Coast is located in the southernmost end of the canal zone, and includes the land on both sides of the Canal entrance (Photo 5-6). In the specific study area (AEE) of this Zone, different types of cover are observed, such as the intermediate secondary forest (2,700.40 ha), mangrove forest (39.30 ha), shrubs (486.76 ha), and grasslands that occupy 1,080.04 ha. This Zone also includes 28,190.85 ha of aquatic ecosystems.

There are three types of forest within the specific study area (AEE): semideciduous tropical lowland forests, dry-season deciduous lowland forests and mangrove forests. There are also an area of flooded savannas dominated by short graminoids.

Types of vegetation are sparse in the area of direct impact (AID) of the Pacific Coast zona (Figure 5-3), and are distributed as follows: 161.05 ha of semideciduos tropical lowland forest (intermediate secondary forest), 24.28 ha of mangrove forest, 110.97 ha of shrubs and 122.65 ha of grasslands. The figures in Table 5-13 easily allows to determined the degree of perturbation existing in the Zone.

Table 5-13
Acreeage (ha) by Category of Vegetative Coverage in Zone 6

Zone 5	Bm	Bsm	Bsi	Bmg	C	M	P-H	Sd	U	A
AEE	0	0	2,700.40	39.30	0	486.76	1,080.04	0	3,018.78	28,190.85
AID	0	0	161.05	24.84	0	110.97	122.66	0	55.87	4,092.18
Total	0	0	2,861.45	64.14	0	597.73	1,202.70	0	3,074.65	32,283.03

Notes: in the Forest column – Bm = mature foresto, Bsm = mature secondary forest, Bsi = intermédiaire secondary forest, Bmg = mangrove forest, C= cativo forest, M = shrubs, P-H = grassland, Sd = bare ground U = urban, A = water

Source: URS Holdings, Inc.

56 species distributed in 30 families (Table 5-14). The Magnoliopsida is the best represented group with 42 species distributed in 22 families. The Liliopsida group presents 12 species belonging to 6 families. The best represented families in the Magnoliopsida group are: Fabaceae with 9 species and Rubiaceae with 5 species. The best represented family of the Liliopsida group is the Poaceae with 6 species.

Table 5-14
Number of Species and Families by Group Within Zona 6

Group	Family	ESpecies
Liliopsida	6	12
Magnoliopsida	22	42
Gymnospermas	0	0
Ferns and Allies	2	2
Total	30	56

Source: Fundación Universidad de Panamá.

Within the secondary forests present in this Zone are intermediate secondary forests (dry-season deciduos tropical forest, latifoliated lowland forests and semideciduos tropical lowland forests) and mangrove forests. The dominant species in the deciduos forest is the *Vitex* sp. Also

observed are trees such as *Xylopia aromatica*, *Tetragastris panamensis*, *Luehea seemannii*, *Cordia alliodora*, *Jacaranda copaia*, *Hura crepitans*, *Pittoniotis trichantha*, *Manilkara zapota*, *Simaba cedron*, *Ficus citrifolia* and *Astronium graveolens*. In the semideciduous forest the dominant tree specie is the *Hymenaea courbaril*, with is associated with the *Astronium graveolens*, *Tetragastris panamensis*, *Copaifera aromatica*, *Spondias mombin*, *Enterolobium cyclocarpum*, *Terminalia amazonia*, *Cordia alliodora*, *Zuelania guidonia*, *Oenocarpus mapora* and *Anacardium excelsum*, among others.

The predominant species in the mangrove forests of the Pacific coast is the *Rhizophora mangle*, followed by *Avicennia germinans*, *Avicennia bicolor*, *Rhizophora racemosa*, *Pelliciera rhizophorae* and *Laguncularia racemosa*. In addition, the fern *Acrostichum aureum* is commonly found.

The predominant species in the shrubs is the *Curatella americana*, mixed with the introduced grasses *Hyparrhenia rufa* y *Saccharum spontaneum*. Certain sparse trees, such as: *Swietenia macrophylla* and *Xylopia aromatic*, are also commonly observed.

In the largest grassland fragment, the dominant species is the *Saccharum spontaneum*, with the presence of a few sparse trees. Some of the tres observed are: *Cecropia peltata*, *Cassia moschata*, *Genipa americana* and *Apeiba tibourbou*, among others. Grasslands are found in some areas in which the dominant specie is the *Hyparrhenia rufa*.

5.2.4 Threatened, Endemic or Endangered Species

The basis used for the definition of threatened, endemic or endangered species was the information included in the Appendixes of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2007), the *Red List Threatened Species* (UICN, 2006) and the *First Report on the Richness and State of Biodiverstiy in Panamá* (ANAM, 2000b).

This report takes into consideration the categories utilized by ANAM and UICN, which include: specie in critical state (Cr), endangered specie (En) and vulnerable specie (Vu). The

categorization of species depends on the situation of the specie populations studied. In the case of the species included in CITES (I, II, III) Appendixes, the objective is the control of its commercialization and thus diminish the pressure on its populations. Appendix I includes the most threatened species. These especies are threatened with extinction and CITES prohibits their international commercial trade, except for non comercial purposes, for example, research. Appendix II includes those species that, although not necessarily threatened with extinction, may become so unless trade is strictly regulate. Appendix III includes those species that any Party has identified as being subject to regulation and needing the co-operation of other Parties to prevent their unsustainable or illegal exploitation.

According to information presented by STRI –USAID-ANAM (1999), the Watershed Monitoring Project (PMCC) data that of the 1,125 species recorded in the General Study Area, 50 are endemic to the Country, according to the 1987 list of Panama’s Flora. According to UICN, of the species found 110 species were threatened (vulnerable), 20 were endangered, y 71 species were not in need of conservation, but are close to become vulnerable. Of the species endemic to Panama, according the the 1987 list of flora, 18 were reported in the Chagres National Park (P. N.); 16 in the protected area of San Lorenzo (former Fort Sherman), Barro Colorado Island and the Soberanía National Park (P. N.); 7 in the Soberanía National Park; 6 are repeated in the Soberanía National Park, Barro Colorado Island and Cocolí; 3 are repeated in all the mentioned sectors except in the southeastern area of the Watershed (Negro Hill), where no endemic species were reported.

The data related to the Specific Study Area of the Project, were obtained after the elaboration of a list based on existing Zone studies , carried out for the purpose of obtaining knowledge regarding the flora and identifying those species in need of protection. Considering the different types of vegetation, 2,930 species were collected. The totalof species included in the list was compared with those species included in the ANAM, UICN and CITES lists.

Table 5-15 shows details regarding the distribution of endemic, threatned, and protected species, taking into account their Zone within the Specific Study Area (AEE) and the institutions which include them as species in need of protection.

Tabla 5-15**Endemic, Threatened, and Protected Species, by AEE Zone and Institution**

Zones	Endemic to the Country	Threatened and Protected			Total
		ANAM	IUCN	CITES	
Atlantic Coast (Zone 1)	14	25	9	16	54
Gatun Locks (Zone 2)	9	14	5	7	34
Gatun Lake (Zone 3)	4	8	4	4	20
Culebra Cut (Zone 4)	2	4	4	0	8
Pacific Locks (Zone 5)	2	7	4	6	11
Pacific Coast (Zone 6)	2	3	4	2	7
	15	32	12	25	62

Source: Elaborated by Fundación Universidad de Panamá (FUDEP)

The greatest number of special interest species is found in the tropical ombrophile evergreen, latifoliated lowland forests located in the Atlantic sector, since the forest fragments in the former Fort Sherman and Fort Davis have only undergone slight alterations, and this favors the presence of numerous species.

5.2.4.1 Atlantic Coast (Zone 1)

The list elaborated for this Zone includes some 427 species, of which 14 are endemic to the Country and 44 are considered threatened and protected. Although there are different types of vegetation in this Zone, the greatest number of reported and protected species are found in the fragments of the tropical ombrophile evergreen, latifoliated lowland forest. On the other hand, 25 of the recorded species have been included in the ANAM lists of species in need of protection. Likewise, 9 species are included in the IUCN *Red List* and 16 in the CITES appendixes. The orchids is the group of plants with the greatest number of species included in these lists. This is due to the abundance of orchids in the area, since most are included in CITES Appendix II. Greater details are included in Table 5-16.

Table 5-16

Endemic, Threatened, and Protected Plant Species in the Specific Study Area (AEE) in the Atlantic Coast (Zone 1)

Family	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	UICN	CITES
Anacardiaceae		Zebrawood or tigerwood		Vu		
Annonaceae	<i>Annona hayesii</i> Saff.		x			
Annonaceae	<i>Annona spraguei</i> Saff.	Negrito			Vu	
Araceae	<i>Anthurium pseudospectabile</i> Croat			En		
Araceae	<i>Dieffenbachia pittieri</i>	Otoe lagarto	x			
Araliaceae	<i>Oreopanax oerstediana</i> Marchal				Vu	
Arecaceae	<i>Bactris coloradonis</i> L.H. Bailey	Caña brava		En		
Arecaceae	<i>Oenocarpus mapora</i> H. Karst.	Maquenque		En		
Bignoniaceae	<i>Parmentiera cereifera</i> Seem.	Árbol de vela		En	En	
Bignoniaceae	<i>Tabebuia guayacan</i> (Seem.) Hemsl.	Guayacán		Vu		
Bignoniaceae	<i>Tabebuia rosea</i> (Bertol.) A.DC.	Roble		Vu		
Bombacaceae	<i>Pachira quinata</i> (Jacq.) W. S. Alverson	Red ceiba		En		
Bombacaceae	<i>Quararibea pterocalyx</i> Hemsl.	Garrocho			Vu	
Burseraceae	<i>Protium tenuifolium</i> Engl.	Copal	X			
Cactaceae	<i>Epiphyllum phyllanthus</i> (L.) Haw.	Cactus		En		
Cecropiaceae	<i>Cecropia longipes</i> Pittier	Guarumo		En	En	
Clusiaceae	<i>Clusia liesneri</i> Maguire	Copé	X			
Combretaceae	<i>Terminalia amazonia</i> (J. F. Gmel.) Exell	Amarillo		Vu		
Connaraceae	<i>Connarus turczaninowii</i> Triana		X			
Euphorbiaceae	<i>Hieronyma alchornoides</i> Allemáo	Zapatero		Vu		
Fabaceae	<i>Platymiscium pinnatum</i> (Jacq.) Dugand	Quirá		Cr		
Gesneriaceae	<i>Diastema racemiferum</i> Benth.			En		
Gesneriaceae	<i>Drymonia serrulata</i> (Jacq.) Mart.			En		
Gesneriaceae	<i>Kohleria tubiflora</i> (Cav.) Hanst.			En		
Heliconiaceae	<i>Heliconia barryana</i> Kress	Platanillo		Cr		
Malpighiaceae	<i>Bunchosia ternata</i> Dobson			En		
Meliaceae	<i>Cedrela odorata</i> L.	Spanish cedar		Cr	Vu	
Myristicaceae	<i>Virola surinamensis</i> (Rol. ex Rottb.) Warb.	Baboen			En	

Family	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	UICN	CITES
Myrsinaceae	<i>Ardisia dweryi</i> Lundell		X	En		
Myrtaceae	<i>Aulomyrcia zetekiana</i> (Standl.) Amshoff		X			
Myrtaceae	<i>Myrcia fosteri</i> Croat		X		Vu	
Myrtaceae	<i>Myrcia gatunensis</i> Standl.	Pimento	x			
Orchidaceae	<i>Aspasia principissa</i> Rchb. f.	Orchid				II
Orchidaceae	<i>Caularthron bilamellatum</i> (Rchb.) R.E. Schult.	Orchid				II
Orchidaceae	<i>Chysis bruennowiana</i> Rchb. f. & Wars.	Orchid				II
Orchidaceae	<i>Dimerandra emarginata</i> (G. Mey.) Hoehne	Orchid				II
Orchidaceae	<i>Epidendrum laucheum</i> Rolfe	Orchid				II
Orchidaceae	<i>Epidendrum schlechterianum</i> Ames	Orchid				II
Orchidaceae	<i>Maxillaria uncatata</i> Lindl.	Orchid				II
Orchidaceae	<i>Oncidium ampliatum</i> Lindt.	Orchid				II
Orchidaceae	<i>Palmorchis powellii</i> (Ames) C. Schweint. & Correll	Orchid				II
Orchidaceae	<i>Pleurothallis verecunda</i> Schltr.	Orchid				II
Orchidaceae	<i>Sobralia fragans</i> Lindl.	Orchid				II
Orchidaceae	<i>Trichocentrum capistratum</i> Linden & Rchb. f.	Orchid				II
Orchidaceae	<i>Vanilla planifolia</i> Jacks. Ex Andrews	Vanilla Orchid				II
Orchidaceae	<i>Vanilla pompona</i> Schiede	West Indian Vanilla Orchid				II
Piperaceae	<i>Peperomia killipi</i> Trel.		x			
Piperaceae	<i>Piper aristolochiaefolium</i> (Trel.) Yunck.	Hinojo	x	En		
Rubiaceae	<i>Hamelia sanguinea</i> Jacq.		x			
Rubiaceae	<i>Rudgea isthmensis</i> Standl.		x			
Rubiaceae	<i>Tocoyena pittieri</i> (Standl.) Standl.	Tocoyena			Vu	
Sapindaceae	<i>Talisia nervosa</i> Radlk.	Mamón de monte		En		
Zamiaceae	<i>Zamia acuminata</i> Oerst. ex Dyer	Zamia		Cr		II
Zamiaceae	<i>Zamia flairchildiana</i> L.D. Gómez	Zamia	x	Cr		II
	TOTALS		14	24	9	16

Notes: In the ANAM and UICN columns , Cr = critically endangered, En = endangered, Vu = vulnerable. In the CITES, II column = Specie included in Appendix II.

Source: Fundación Universidad de Panamá (FUDEP)

The environments within area of direct impact (AID) in zone 1 are relatively altered. At present there are dredged material disposal sites in these sectors, and two additional disposal sites will be established in areas presently covered mainly by shrubland, in addition to fragments of secondary forests of relative similarity with the environments described in this section for the specific study area (AEE) (see Figure 5-2).

5.2.4.2 Gatun Locks (Zone 2)

For this study FUDEP elaborated a list of 460 species recorded in the different types of vegetation in this Zone. Of the total species recorded, 34 are included in the revised lists of endemic, threatened, and protected species. Most of the species in need of protection are located in fragments of the tropical ombrophile evergreen, latifoliated lowland forest; however, four species are found in the shrubs and grasslands: *Connarus turczaninowii*, *Terminalia amazonia*, *Vatairea erythrocarpa* and *Drymonia serrula*.

According to the different lists of protected species, the following was found in the areas of specific study (AEE): 9 endemic species, 14 species included in the ANAM lists, 5 species included in the IUCN *Red List*, 7 are included in the CITES Appendix II and 26 species are included in one or more of the three lists of threatened or protected species (Table 5-17-a).

Table 5-17-a
Endemic, Threatened, and Protected Species in the Specific Study Area (AEE) of Gatun Locks (Zone 2)

Family	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	IUCN	CITES
Araceae	<i>Anthurium pseudospectabile</i> <i>Croat</i>	Anthurium		En		

Family	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	UICN	CITES
Arecaceae	<i>Bactris coloradonis</i> L.H. Bailey	Caña brava		En		
Arecaceae	<i>Oenocarpus mapora</i> H. Karst.	Maquenque		En		
Bignoniaceae	<i>Tabebuia rosea</i> (Bertol.) A.DC.	Roble		Vu		
Bombacaceae	<i>Quararibea pterocalyx</i> Hemsl.	Garrocho			Vu	
Burseraceae	<i>Protium tenuifolium</i> Engl.	Copal	x			
Cactaceae	<i>Epiphyllum phyllanthus</i> (L.) Haw.	Cactus		En		
Clusiaceae	<i>Clusia liesneri</i> Maguire		x			
Combretaceae	<i>Terminalia amazonia</i> (J. F. Gmel.) Exell	Amarillo		Vu		
Connaraceae	<i>Connarus turczaninowii</i> Triana		x			
Cyatheaceae	<i>Cyathea multiflora</i> Sm.	Tree fern				II
Cyatheaceae	<i>Cyathea petiolata</i> (Hook.) R. M. Tryon	Tree fern				II
Euphorbiaceae	<i>Hieronyma alchornoides</i> Allemáo	Zapatero		Vu		
Fabaceae	<i>Platymiscium pinnatum</i> (Jacq.) Dugand	Quirá		Cr		
Fabaceae	<i>Vatairea erythrocarpa</i> Ducke	Amargo		Vu		
Gesneriaceae	<i>Diastema racemiferum</i> Benth.			En		
Gesneriaceae	<i>Drymonia serrulata</i> (Jacq.) Mart.			En		
Gesneriaceae	<i>Kohleria tubiflora</i> (Cav.) Hansa.			En		
Myristicaceae	<i>Virola surinamensis</i> (Rol. Ex Rottb.) Warb.	Baboen			En	
Myrsinaceae	<i>Ardisia bartlettii</i>					
Myrsinaceae	<i>Ardisia dwery</i> Lundell		x	En		

Family	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	UICN	CITES
Myrtaceae	<i>Aulomyrcia zetekiana</i>		x			
Myrtaceae	<i>Myrcia fosteri</i> Croat		x		Vu	
Myrtaceae	<i>Myrcia gatunensis</i> Standl.	Pimento	x			
Orchidaceae	<i>Aspasia principias</i>	Orchid				II
Orchidaceae	<i>Campylocentrum costatum</i>	Orchid				II
Orchidaceae	<i>Sobralia fragans</i>	Orchid				II
Orchidaceae	<i>Vanilla pauciflora</i> Dressler	Vanilla Orchid				II
Orchidaceae	<i>Vanilla pompona</i>	West Indian Vanilla				II
Rubiaceae	<i>Hamelia sanguinea</i>		x			
Rubiaceae	<i>Rudgea isthmensis</i>		x			
Rubiaceae	<i>Tocoyena pittieri</i>	Tocoyena			Vu	
Rutaceae	<i>Zanthoxylum panamense</i> P. Wilson	Alcabú			En	
Sapindaceae	<i>Talisia dwyeri</i>			En		
	TOTALS		9	14	5	7

Notes: In the ANAM and UICN columns, Cr = critically endangered, En = endangered, Vu = vulnerable.

In the CITES, II column = Specie included in Appendix II.

Source: Fundación Universidad de Panamá (FUDEP)

In the area of direct impact in the zone of the Gatun Locks, CEREB-UP identified a total of 300 species in the 8 hectares sampled, of which 3 are endemic to the Country, 9 species are included in the ANAM lists, 2 are included in the IUCN *Red List* (including the NT category or near threatened), and 3 are included in the CITES Appendix II (Table 5-17-b).

Tabla 5-17-b
Endemic, Threatened, and Protected Species in the Area of Direct Impact (AID) of the Gatun Locks (Zone 2)

Family	Specie	Common Name	Estatus de las especies			
			Endemic to the Country	ANAM	UICN	CITES
Arecaceae	<i>Attalea butyracea</i> (Mutis ex L. f.) Wess. Boer	Royal palm		Vu		

Family	Specie	Common Name	Estatus de las especies			
			Endemic to the Country	ANAM	UICN	CITES
Burseraceae	<i>Protium panamense</i> (Rose) I.M. Johnst.				NT	
Burseraceae	<i>Protium tenuifolium</i> Engl.	Copal	x			
Burseraceae	<i>Trattinnickia aspera</i> (Standl.) Swart	Caraña hedionda	En			
Combretaceae	<i>Terminalia amazonia</i> (J. F. Gmel.) Exell	Amarillo		Vu		
Connaraceae	<i>Connarus turczaninowii</i> Triana		x			
Cyatheaceae	<i>Cyathea multiflora</i> Sm.	Tree fern				II
Cyatheaceae	<i>Cyathea petiolata</i> (Hook.) R. M. Tryon	Tree fern				II
Euphorbiaceae	<i>Hieronyma alchornoides</i> Allemáo	Zapatero		Vu		
Fabaceae	<i>Inga hayesii</i> Benth.	Guabito			NT	
Fabaceae	<i>Vatairea erythrocarpa</i> Ducke	Amargo		Vu		
Gesneriaceae	<i>Drymonia serrulata</i> (Jacq.) Mart.			En		
Myrtaceae	<i>Myrcia gatunensis</i> Standl.	Pimento	x			
Orchidaceae	<i>Vanilla pauciflora</i> Dressler	Vanilla Orchid				II
	TOTALS		3	9	2	3

Notes: In the ANAM and UICN columns, Cr = critically endangered, En = endangered, NT = almost threatened, Vu = vulnerable.

In the CITES, II column= Sspecie included in Appendix II.

Source: URS Holdings, Inc. con datos de CEREB-UP (2005).

5.2.4.3 Gatun Lake (Zone 3)

In the specific study area (AEE) of the zone bordering Gatun Lake, 412 species were found in the different types of vegetation (grasslands, shrubs, secondary forests and mature forests). Of the total number of species reported, 20 are included in the lists of species in need of protection (Table 5-18). Four (4) endemic species were identified, 8 in the ANAM lists, 4 in the IUCN *Red List*, and 4 in the CITES appendixes. Although the landscape is dominated by pasture land and shrubs, threatened and protected species are found in the forest fragments.

Table 5-18

Endemic, Threatened, and Protected Species in the Specific Study Area (AEE) of Gatun Lake (Zone 3)

Family	Specie	Common Name	Specie Status			
			Endemic to the Country	ANAM	UICN	CITES
Arecaceae	<i>Bactris coloradonis</i>	Caña brava		En		
Arecaceae	<i>Oenocarpus mapora</i> H. Karst.	Maquenque		En		
Bignoniaceae	<i>Tabebuia guayacan</i> (Seem.) Hemsl.	Guayacán		Vu		
Bignoniaceae	<i>Tabebuia rosea</i>	Roble		Vu		
Burseraceae	<i>Protium panamense</i> (Rose) I. M. Johnst.	Copal				
Burseraceae	<i>Protium tenuifolium</i> Engl.	Chutrá	x			
Combretaceae	<i>Terminalia amazonia</i> (J. F. Gmel.) Exell	Amarillo		Vu		
Fabaceae	<i>Dipteyx oleifera</i> Benth.	Almendro				III
Gesneriaceae	<i>Drymonia serrulata</i>			En		
Gnetaceae	<i>Gnetum leyboldii</i>			Cr		
Moraceae	<i>Brosimum guianensis</i>			Vu		
Myristicaceae	<i>Virola surinamensis</i> (Rol. Ex Rottb.) Warb.	Baboen			En	
Myrtaceae	<i>Aulomyrcia zetekiana</i>		x			
Myrtaceae	<i>Myrcia fosteri</i>		x		Vu	
Myrtaceae	<i>Myrcia gatunensis</i>	Pimento	x			
Orchidaceae	<i>Oncidium stipitatum</i>	Orchid				II
Orchidaceae	<i>Palmorchis powellii</i>	Orchid				II
Orchidaceae	<i>Vanilla planifolia</i>	Vanilla Orchid				II
Rubiaceae	<i>Tocoyena pittieri</i>	Tocoyena			Vu	
Rutaceae	<i>Zanthoxylum panamense</i>	Arcabú			En	
			4	8	4	4

Notes: 0In the ANAM and UICN columns, Cr = critically endangered, En = endangered, Vu = vulnerable.

In the CITES, I columnI = Specie included in Apendix II.

Source: Fundación Universidad de Panamá (FUDEP)

There are no terrestrial environments within the area of direct impact (AID) of zone 3; and the aquatic environments, which include the dredged material disposal sites, will include the Canal expansión route (see Figure 5-2).

5.2.4.4 Culebra Cut (Zone 4)

The area of direct impact (AID) in the zone of Culebra Cut is a narrow strip along the Canal where most of the land is covered by grasslands and shrubs. However, in the specific study area (AEE), towards the North and bordering with the mouth of the Chagres river in the Canal, fragments of secondary mature forests of the semideciduos tropical lowland type, are observed. In these forest fragments is where the highest diversity of plant species is found. This study took into consideration the vegetation of the grasslands and shrubs, to analyze the presence of threatened and protected species. Eight (8) species considered threatened and protected were found. Within this group, 2 species are endemic, 4 are included in the ANAM lists, 4 are included in the IUCN *Red List*, but none of the species reported for this Zone appear in CITES appendixes (Table 5-19).

Table 5-19
Endemic, Threatened, and Protected Species in the Specific Study Area of Culebra Cut
(Zone 4)

Famiy	Specie	Common Name	Estatus de las especies			
			Endemic to the Country	ANAM	IUCN	CITES
Annonaceae	<i>Annona hayesii</i> Saff.		x			
Annonaceae	<i>Annona spraguei</i> Saff.	Negrito			Vu	
Bignoniaceae	<i>Tabebuia guayacan</i> (Seem.) Hemsl.	Guayacán		Vu		
Bombacaceae	<i>Pachira quinata</i> (Jacq.) W. S. Alverson	Red ceiba		En		
Cecropiaceae	<i>Cecropia longipes</i> Pittier	Guarumo		En	En	
Meliaceae	<i>Cedrela odorata</i> L.	Spanish cedar		Cr	Vu	
Myrtaceae	<i>Myrcia gatunensis</i> Standl.	Pimento	x			
Rutaceae	<i>Zanthoxylum panamense</i> P. Wilson	Arcabú			En	
	Totales		2	4	4	0

Noeas: In the ANAM and UICN column, Cr = critically endangered, En = endangered, Vu = vulnerable.

In the CITES, II column = Specie included in Appendix II.

5.2.4.5 Pacific Locks (Zone 5)

Fragments of secondary forests, in addition to fragments of shrubs, grassland, fresh water wetlands, and mangrove forests were observed in this Zone. This ecosystem variability determines the diversity of species found in this Sector.

After the revision of previous reports, FUDEP elaborated a list of 197 plant species. Of the total species recorded, 11 are considered threatened and protected. In this group 2 species are endemic, 7 are included in the ANAM lists, 4 are included in the IUCN *Red List*, but none of the recorded species appear in the CITES appendixes. Most of these species are found in the fragments of secondary forest. However, the *Annona hayesii* and *Annona spraguei* can be observed in the shrubs. (Table 5-20-a)

Table 5-20-a
Endemic, Threatened, and Protected Species in the Specific Study Area (AEE) of the Pacific Locks

Family	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	IUCN	CITES
Anacardiaceae	<i>Astronium graveolens Jacq.</i>	Zebra wood or tiger wood		Vu		
Annonaceae	<i>Annona hayesii Saff.</i>		X			
Annonaceae	<i>Annona spraguei Saff.</i>	Negrillo			Vu	
Bignoniaceae	<i>Tabebuia guayacan (Seem.) Hemsl.</i>	Guayacán		Vu		
Bombacaceae	<i>Pachira quinata (Jacq.) W. S. Alverson</i>	Red ceiba		En		
Cecropiaceae	<i>Cecropia longipes Pittier</i>	Guarumo		En	En	
Combretaceae	<i>Terminalia</i>	Amarillo		Vu		

Family	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	UICN	CITES
	<i>amazonia (J. F. Gmel.) Exell</i>					
Fabaceae	<i>Dalbergia retusa Hemsl.</i>	Cocobolo		En		
Meliaceae	<i>Cedrela odorata L.</i>	Spanish cedar		Cr	Vu	
Myrtaceae	<i>Myrcia gatunensis Standl.</i>	Pimento	x			
Rutaceae	<i>Zanthoxylum panamense P. Wilson</i>	Arcabú			En	
	Totals		2	7	4	0

Notes: In the ANAM and UICN columns, Cr = critically endangered, En = endangered, Vu = vulnerable.

In the CITES, II column = Specie included in Sppendix II.

Source: Preparado por FUDEP

In the Area of Direct Impact (AID) of the Pacific Locks zone, CEREB-UP (2005) documented 412 species, in a total of 12 ha inventoried in the field, of which 3 are species endemic to the Country, 14 are included in the ANAM lists, 9 are in the IUCN *Red List* (including the NTcategory or almost threated) and 2 in the CITES appendixes (Table 5-20-b).

Table 5-20-b

Endemic, Threatened, and Protected Species Within the Area of Direct Impact (AID) of the Pacific Locks (Zone 5)

Family	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	UICN	CITES
Anacardiaceae	<i>Astronium graveolens Jacq.</i>	Zebrawood or tigerwood		Vu		
Annonaceae	<i>Annona hayesii Saff.</i>		x			
Arecaceae	<i>Attalea butyracea (Mutis ex L. f.) Wess. Boer</i>	Royal palm		Vu		
Bignoniaceae	<i>Tabebuia guayacan (Seem.) Hemsl.</i>	Guayacán		Vu		
Bombacaceae	<i>Cavanillesia platanifolia (Bonpl.) Kunth</i>				NT	

Family	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	UICN	CITES
Bombacaceae	<i>Pachira quinata</i> (Jacq.) W. S. Alverson	Red ceiba		En		
Burseraceae	<i>Protium panamense</i> (Rose) I.M. Johnst.				NT	
Cecropiaceae	<i>Cecropia longipes</i> Pittier	Guarumo		En	En	
Combretaceae	<i>Terminalia amazonia</i> (J. F. Gmel.) Exell	Amarillo		Vu		
Fabaceae	<i>Dalbergia retusa</i> Hemsl.	Cocobolo		En		
Fabaceae	<i>Inga hayesii</i> Benth.	Guabito			NT	
Fabaceae	<i>Lennea viridiflora</i> Seem.				Vu	
Gesneriaceae	<i>Drymonia serrulata</i> (Jacq.) Mart.			En		
Meliaceae	<i>Cederla</i> cf. <i>Fissilis</i> Vell.	Cedar		Vu	En	
Meliaceae	<i>Cedrela odorata</i> L.	Spanish cedar		Cr	Vu	
Meliaceae	<i>Swietenia macrophylla</i> King	Mahogany		Cr	Vu	II
Myrtaceae	<i>Myrcia gatunensis</i> Standl.	Pimento	x			
Polygonaceae	<i>Coccoloba</i> cf. <i>manzinellensis</i> Beur.	Uvero	x			
Pteridiaceae	<i>Ceratopteris pteridoides</i> (Hook.) Hieron.	Floatng fern		Vu		
Rhizophoraceae	<i>Rhizophora mangle</i> L.	Red mangrove		Vu		
Theaceae	<i>Pelliciera rhizophorae</i> Planch. & Triana	Mangrove tree		Vu		
Totals			3	14	9	2

Notes: In the ANAM and UICN columns, Cr = critically endangered, En = endangered, NT = almost threatened, Vu = vulnerable. In the CITES, II column = Specie included in Appendix II.

Source: URS Holdings, Inc., con datos de CEREB-UP (2005).

5.2.4.6 Pacific Coast (Zone 6)

As a result of human intervention ,this is the Zone with the greatest alterations to the natural ecosystems. The landscape is dominated by grasslands and shrubs. Nonetheless, this Zone includes some fragments of secondary forest, mangroves and swamps. As in the previous Zone,

the alterations result in a variability of ecosystems and species. The records consulted by FUDEP for this study allowed the elaboration of a list of 56 species for the specific study area (AEE), of which 7 are included in the lists of protected species. On the other hand, the ANCON-TNC (1996a) field studies conducted in the former military installations known as “HOROKO”, and which include the western portion of Zone 6 of the specific study area (AEE) of the Project within its research area, found 381 plant species in the secondary forests of the semideciduous tropical lowland type alone.

According to the list elaborated by FUDEP, two (2) endemic species were recorded in the Pacific Coast, of which three (3) are included in the ANAM lists, four (4) in the IUCN *Red List*, and two (2) in the CITES appendixes. (Table 5-21)

Table 5-21
Endemic, Threatened, and Protected Species in the Specific Study Area of the Pacific Coast
(Zone 6)

Family	Species	Common Name	Species Status			
			Endemic to the Country	ANAM	IUCN	CITES
Cecropiaceae	<i>Cecropia longipes</i> Pittier	Guarumo		En	En	
Meliaceae	<i>Swietenia macrophylla</i> King	Mahogany		Cr	Vu	II
Myristicaceae	<i>Virola surinamensis</i> (Rol. Ex Rottb.) Warb.	Baboen			En	
Myrtaceae	<i>Myrcia fosteri</i> Croat		x		Vu	
Orchidaceae	<i>Vanilla planifolia</i>	Vanilla Orchid				II
Rhizophoraceae	<i>Rhizophora mangle</i> L.	Red Mangrove		Vu		
Turneraceae	<i>Turnera</i>		x			

Famiy	Specie	Common Name	Species Status			
			Endemic to the Country	ANAM	UICN	CITES
	<i>panamensis</i>					
	TOTALS		2	3	4	2

Notes: In the ANAM and UICN columns, Cr = critically endangered, En = endangered, Vu = vulnerable.

In the CITES, II column = Specie included in Appendix II.

Source: Fundación Universidad de Panamá (FUDEP)

5.2.5 Indicator Species

Indicator species are those that offer information regarding the status or health of the ecosystems in which they are found. In addition, these species are indicative of the different stages of ecosystem development, weather conditions, type of soil, and in some cases may indicate anthropological perturbances in the ecosystem. The species selected to identify the flora shall be those present in their natural state in the different stages of vegetal succession, whose affectation or disappearance in proper climatic and soil conditions could be considered the result of are perturbations. Accordingly, these perturbations shall be considered alterations of the ecosystems. Within these approaches, specie populations and particular species are proposed to serve as indicators for the area of direct impact (AID) as well as for the specid study area (AEE) and AEG of the Project.

The sources utilized regarding the aspects of the flora include Correa et al. (2004), STRI-USAID-ANAM (1999), and Croat (1978). With regard to the species utilizaed as indicators within the AEG corresponding to the Panama Canal Watershed, STRI-USAID- ANAM (1999) indicates that, according to the peasants, the following species indicate the poor quality of the soil: *Gleichenia* sp. (helechillo), *Dicranopteris* sp. (helechillo), *Matayba glaberrima* (matillo), *Bursera simaruba* (almácigo), and *Cochlospermum vitifolium* (poro poro).

The report has considered indicator species those species which are present in their natural state in different stages of vegetal succession (Table 5-22). Assuming that the climatic and soil conditions in the region are adequate for the establishment of forests, the presence of another type of vegetation (shrubs and grassland) is considered the result of perturbations in the area. Accordingly, changes in the landscape are indicators of the alterations suffered by the natural ecosystems (forests).

Table 5-22
Indicator Plant Species

Family	Specie	Common Name	Stage of Ecosystem Development
Poaceae	<i>Hyparrhenia rufa</i>	Thatching grass	Pioneer Specie
Poaceae	<i>Saccharum spontaneum</i>	Paja blanca	Pioneer Specie
Cecropiaceae	<i>Cecropia peltata</i>	Trumpet tree	Pioneer Specie
Bombacaceae	<i>Ochroma pyramidale</i>	Balso	Pioneer Specie
Sterculiaceae	<i>Guazuma ulmifolia</i>	West Indian elm	Pioneer Specie
Fabaceae	<i>Gliricidia sepium</i>	Quickstick	Secondary Forest
Clusiaceae	<i>Vismia macrophylla</i>	Pinta mozo	Secondary Forest
Annonaceae	<i>Annona spraguei</i>	Negrito	Secondary Forest
Araliaceae	<i>Schefflera morototoni</i>	Mangabé	Secondary Forest
Tiliaceae	<i>Luehea semannii</i>	Guácimo colorado	Secondary Forest
Melastomataceae	<i>Miconia argentea</i>	Dos caras	Secondary Forest
Boraginaceae	<i>Cordia alliodora</i>	Laurel	Secondary Forest
Fabaceae	<i>Swartzia simplex</i>	Naranjillo	Secondary Forest
Combretaceae	<i>Terminalia amazonia</i>	Amarillo	Mature Forest
Meliaceae	<i>Cedrela odorata</i>	Cedro or Spanish cedar	Mature Forest
Euphorbiaceae	<i>Hieronyma alchorroides</i>	Zapatero	Mature Forest
Fabaceae	<i>Hymenaea coubaril</i>	Algarrobo	Mature Forest
Fabaceae	<i>Peltogyne purpurea</i>	Nazareno or	Mature Forest

Family	Specie	Common Name	Stage of Ecosystem Development
		Purple heart	
Lecythidaceae	<i>Gustavia superba</i>	Membrillo	Mature Forest
Fabaceae	<i>Dipteryx oleifera</i>	Almendro	Mature Forest
Moraceae	<i>Poulsenia armata</i>	Cucuá	Mature Forest
Euphorbiaceae	<i>Sorocea affinis</i>	Cauchillo	Mature Forest
Myristicaceae	<i>Virola sebifera</i>	Gorgorán	Mature Forest
Nyctaginaceae	<i>Guapira costaricana</i>	Mala sombra	Mature Forest
Bignoniaceae	<i>Tabebuia guayacan</i>	Guayacán	Mature Forest
Bombacaceae	<i>Ceiba pentandra</i>	Ceibo	Mature Forest
Fabaceae	<i>Platymiscium pinnatum</i>	Quirá	Mature Forest
Tiliaceae	<i>Apeiba membranacea</i>	Peine de mono	Mature Forest
Fabaceae	<i>Myroxylum balsamum</i>	Bálsamo	Mature Forest
Fabaceae	<i>Dalbergia retusa</i>	Cocobolo	Mature Forest

Note. The presence of an abundance of herbaceous epiphytes (bromeliads, orchids, and peperomias) is indicative of the development of mature forests.

Source: Fundación Universidad de Panamá (FUDEP)

The interpretation of the status of a forest should be based on all the tree species present and not in only one specie. Although it is true that there are pioneer species indicative of the establishment of a new forest, it is also true that these same species may appear in forests in a second stage of development. The presence within a forest of trees such as the *Cecropia peltata* is an example. Although the *Cecropia* is a pioneer specie, when found mixed with different species, it is likely in a secondary forest.

In this study, the presence of exotic herbaceous species such as the *Hyparrhenia rufa* and the *Saccharum spontaneum* is interpreted as ecosystems that have been highly perturbed by human activities. On the other hand, the presence of well-developed trees of the *Ceiba pentandra*, *Hieronyma alchornoides*, *Terminalia amazonia*, *Poulsenia armata* and *Virola sebifera* species, indicates the existence of a mature forest. This will indicate that during a long period of time there have been no significant perturbances and that the ecological relations must function

naturally. The presence of species such as the *Guazuma ulmifolia*, *Cecropia peltata*, *Ochroma pyramidale* and *Vismia macrophylla* indicate the presence of a secondary forest. On the other hand, the abundance of the species of the *Asteraceae* family (composites) is indicative of a young forest.

Indicator species by Zone of the specific study area (AEE) are described below:

5.2.5.1 Atlantic Coast (Zone 1)

There is a fragment of a tropical ombrophile evergreen, latifoliated lowland forest in the Atlantic coast which present a set of species recorded as typical of a forest in an advance stage of vegetal succession. There are species in these forests, such as the *Ceiba pentandra*, *Poulsenia armata*, *Sorocea affinis*, *Virola sebifera* and *Gustavia superba*, which are indicators of a mature forest and associated to an abundance of epiphyte species (orchids, bromeliads and peperomias). Although these species are indicators of old-growth forests, they cannot be classified as a primary forest due to the presence of the *Tabebuia rosea*, *Annona spraguei*, *Gliricidia sepium* y *Luehea seemannii*, which are indicative of younger forests.

5.2.5.2 Gatun Locks (Zone 2)

The fragments of tropical ombrophile evergreen, latifoliated lowland forest in this Zone have a mix of species typical of a young secondary forest and a late secondary forest, which is indicative that these forests have been altered, where species representative of the natural ecosystem are not present. The *Hieronyma alchornoides*, *Terminalia amazonia*, *Ceiba pentandra*, *Gustavia superba* and *Poulsenia armata* are among the mature forest species found. Observed among the secondary forest species are the: *Cordia alliodora*, *Schefflera morototoni* and *Luehea seemannii*.

5.2.5.3 Gatun Lake (Zone 3)

Most of the Zone's environment has been altered for the establishment of farming and animal husbandry activities (farming and cattle raising). The forest fragments in the intervened areas are poor in the number of tree species per hectare, condition to be interpreted as a highly altered forest ecosystem. This indicates the the natural ecological processes are not developing optimally. Among the species present in these areas are: *Luehea seemannii*, *Tabebuia rosea*, *Cordia alliodora* and *Vismia macrophylla* (indicadors of a secondary forest) and *Apeiba membranaceae*, *Tabebuia guayacan* and *Virola sebifera* (indicador of a mature forest).

5.2.5.4 Culebra Cut (Zone 4)

The landscape in this Zone is dominated by shrubs and grasslands, result of activities related to Canal operations. Fragments of a semideciduous tropical lowland forest are observed in the North sector, adjacent to the mouth of the Chagres River. These forest fragments present species of mature forests and secondary forests, and thus classified are late-secondary forest. The following species are observed in the mature forest: *Tabebuia guayacan*, *Terminalia amazonia*, *Dalbergia retusa*, *Platymiscium pinnatum* and *Miroxylum balsamum*. Among the species typical of a secondary forest are *Apeiba tibourbou*, *Tabebuia rosea* y *Cecropia peltata*.

5.2.5.5 Pacific Locks (Zone 5)

This Zone has been highly altered as a result of construction activities and the operation of the Panama Canal. Here we can find some fragments of a semideciduous tropical lowland forest, which, based on the species found, is classified as a secondary forest. Frequently observed species are the *Annona hayesii*, *Ochroma pyramidale*, *Cordia alliodora*, *Cecropia peltata*, *Guazuma ulmifolia* and *Apeiba tibourbou*. All these species are typical of a secondary forest.

5.2.5.6 Pacific Coast (Zone 6)

Fragments of a semideciduous tropical lowland forest remain in this Zone, which, because of its flora composition, are similar to the forests previously described. The presence of *Cecropia peltata*, a pioneer specie present in secondary forests, is frequent in these forests.

5.3 Forest Inventory

5.3.1 Forest Plantations in the Environmental Study Area

At present, forest plantations (2856.09 ha) within the General Study Area are located in the Don Bosco sector (Chilibre), southeast of the Chagres National Park, in the communities of Nuevo Chagres, Nuevo San Juan, Nuevo Paraíso and neighboring sectors, and in the area of Gatun River. Towards the eastern side of the Watershed, forest plantations are located to southeast and southwest roeste of the Barro Colorado Natural Monument, in the sectors between Lagartera, El Cañito and Burunga. In addition, some plantations may be observed in the east side of Gatun Lake, in the area of La Ullama. (Figures 5-4 and 5-5).

The common teak (*Tectona grandis*) is the comercial species most utilized for reforestation purposes in the Canal watershed. According a STRI-USAID-ANAM (1999) publication, Filo de Santa Rita and the region north of Alhajuela Lake, the area southeast of Barro Colorado Island, and the sector between the Transisthmian Highway and Gatun Lake are among the areas were this species is commonly found.

5.3.2 Area of Direct Impact

According to the SIG vegetative cover map prepared for this EIA, base don aerial photographas, there were no forest plantations identified within the area of direct impact (AID) (Figures 5-4 and 5-5).

5.3.3 Methodology and Data Processing

Taking into account that there are neither forest plantations nor natural forests within the Project's area of direct impact (AID) that can be used for foretal purposes, an analysis of the forest cover in the Project footprints, in accordance with CEREB-UP (2005) data. These data were used to estime the characteristics and number of tres for comercial use.

The study carried out by CEREB-UP (2005), sampled six (6) sites in the Atlantic sector (Figure 5-4) and 13 sites in the Pacific sector (Figure 5-5), where coordinate and measurements mediciones [total height and diameter at breast height(DBH)] of trees present were taken.

The data presented in Annex 7 of the CEREB-UP (2005) study was used to estimate the number of trees per hectare of each category of forest coverage sampled in the area of direct impact (AID) to then estimate the number of trees to be felled during the construction phase of the Project. For purposes of this inventory, “tree” refers to a woody species individual with a BHD larger than 10 cm.

5.3.4 Results

The estimated tree density, percentage of trees with a BHD greater than 50 cm, and percentage of total tree height of over 20 m in the land surfaces of the Project footprints with forest coverage (mature secondary forest, intermediate secondary forest or mangrove forest) is shown in Table 5-23.

Table 5-23

Characteristics of Trees in the Area of Direct Impact (AID) and Project Footprints

Type of Coverage	Number of Trees in the Project Footprints	Hectares in the Project Footprints	Trees/ha	% BHD >20 cm	%BHD >50 cm	%Total Height >= 15 m	%Total Height >= 20 m
Mature Secondary Forest	6,026	13.9	433.5	57.6	10.5	40.7	17.6
Intermediate Secondary Forest	53,222	432.7	123.0	58.9	8.5	65.0	28.0
Mangrove Forest	2,463	22.6	109.0	36.7	0.9	79.8	31.2

Source: URS Holding, Inc., con datos del Anexo 7 de CEREB-UP (2005)

Table 5-24**Total Estimated Density and Number of Principal Forest Species with Commercial Value
in the Project Footprints**

Spece	Density(Trees/ha)		Total Number of Trees
	Mature Secondary Forest	Intermediate Secondary Forest	
Jobo	7.5	6.5	2917
Espavé	13	4.5	2128
Tachuelo	0.5	2.5	1089
Laurel	8	1.5	760
Zorro	18.5	1	690
Cedro	0.5	1.5	656
Corotú	0.5	1.5	656
Cortezo	3.5	0.5	265
Amarillo	5	0	70
María	3.5	0	49
Higuerón	3.5	0	49
Mahogany	0.5	0	7
Guayacán	0.5	0	7

Source: URS Holdings, Inc., con datos del Anexo 7 de CEREB-UP (2005)

5.4 Inventory of Exotic, Endemic, or Endangered Species

Another important aspect to take into consideraton is the existence of exotic plant introduced into the Watershed area, and which, with the passage of time have become part of the area's flora. This is the case of species such as the mango (*Mangifera indica*), the cashew or marañón (*Anacardium occidentale*), long coriander or culantro (*Eryngium foetidum*), araucaria (*Araucaria excelsa*), coconut (*Cocos nucifera*), oil palm (*Elaeis oleifera*), and the grass known as wild sugarcane (*Saccharum spontaneum*). This situation has probably resulted from the utilization of the area as a transit route during the colonial period and the construction and operation of the Canal (ANCON, 1995). See section 5.2.4.

5.5 Characterization of the Fauna

This section presents the most important aspects relative to the fauna found in the AEG, specific study area (AEE) and area of direct impact (AID) of the Canal Watershed Expansion Project. Information obtained from a series of reports prepared by the ACP (ACP 2006 c; ACP 2006 l; ACP 2006 n; ACP - ANAM 2006), and technical studies performed by or for the ACP in preparation for the environmental impact study for the third set of locks by CEREB - UP (2005); FACINET/CCML-ACP (2005); The Louis Berger Group, Inc. (2004 a, 2004 b, 2004 c, 2004 d); FACINET-CCML-ACP (2004); URS Holdings, Inc. (2004b); ACP – UP (2003) were used to characterize the terrestrial, aquatic, and marine fauna. Also used were scientific articles and reports on the inventory and monitoring of the Canal watershed generated in different periods: Ibáñez et al. (2002); Ibáñez et al. (2001); Condit et al (2001); Tejera et al. (1995); Gutiérrez et al. (1995); ANCON (1995); D’Croz et al. (1994). Also considered were additional information sources related to other investigations carried out regarding species present in this Zone: ANCON – TNC (1996a,b), Garcés (2002); Mou Sue and Chen (1990); Mou Sue et al. (1990); Montgomery et al. (1982); Schad et al. (1981); and MacLaren (1967).

5.5.1 General Fauna Diversity in the Environmental Study Area

5.5.1.1 Species Richness

With regards to studies conducted for the AEG, ANCON (1995) published an Ecological Assessment of the Panama Canal Watershed (*Evaluación Ecológica de la cuenca Hidrográfica del Canal de Panamá*) and presented the following data concerning the richness of species in this region:

- Amphibious species 65
- Reptile species 98
- Bird species 564
- Mammal species 159

Condit et al. (2001) subsequently discussed the status of the Canal watershed and its biodiversity in the year 2000 based on studies conducted over several years by researchers from the Smithsonian Institute and collaborators. As regards to the species richness in the Canal watershed, or General Study Area (AEG), the following numbers point out that knowledge regarding the diversity of certain vertebrate groups in the region had increased significantly over a period of 5 to 6 years:

- Amphibious species: 93
- Bird species: 650

According to the number of species in the above-mentioned studies, the total richness of terrestrial vertebrate species in the Canal watershed amounts to some 1,000 species.

Investigations performed regarding the vertebrate fauna in the specific study area (AEE) and the Area of Direct Impact (AID), also indicate the presence of a large diversity of species. The presence of 1,170 species is forecasted among the terrestrial and aquatic vertebrate fauna. This vertebrate fauna includes five classes, 67 orders and 222 families, as shown in Table No.5-25.

Table 5-25
Potential Diversity of Vertebrates in the Specific Study Area (AEE) and Area of Direct Impact (AID) of the Panam Canal Expansion Project

Class	Orders	Families	Species	Comments
Mammals	9	31	139	<ul style="list-style-type: none"> • 1 aquatic species • 81 bat species • 2 species endemic to the Country
Birds	20	69	530	<ul style="list-style-type: none"> • 134 migratory species • 1 specie endemic to the Country
Reptiles	3	14	63	<ul style="list-style-type: none"> • 1 lizard endemica to the Country

Class	Orders	Families	Species	Comments
				<ul style="list-style-type: none"> • 1 snake endemic to the Country
Amphibians	2	8	46	<ul style="list-style-type: none"> • 1 frog endemic to the Chagres watershed
Fish	33	100	392	<ul style="list-style-type: none"> • 320 marine species • 33 marine species present in both lakes
Totals	67	222	1,170	<ul style="list-style-type: none"> • 6 species endemic to the Country

Source: URS Holdings, Inc., ampliando a CEREB-UP (2005)

With regards to the presence of aquatic fauna (fresh and salt water), different studies carried out within the area of direct impact (AID), Pacific ocean and Atlantic ocean entrance to the Panama Canal, and Gatun and Miraflores lakes, show a high diversity (given the variety of existing environments). A recent study (URS Holdings, Inc. 2004b) concluded that the approximate number of aquatic species was 1,061, including fish, mollusks, echinoderms, crustaceans, corals, aquatic insects, zooplanktons (cladocerans, copepods, polychaetes, crustaceans), hydrozoans, oligochaets, brachiopods, and others. This would represent some 669 species in addition to those included in Table 5-25, for a total of some 1,839 species.

5.5.1.2 Mammals

It is important to note that within the AEG, in the remote areas of the Upper Chagres River Watershed and Protector Forest, and San Lorenzo Protected Landscape (former Fort Sherman), the fauna in general is rather complete and in good condition, where sensitive mammal species such as large cats, tapirs, peccaries, and red-spider monkeys are important components (Ibáñez et al., 2002). There are 145 mammal species within the AEG (ANAM, 2005). Although hunting is quite noticeable in the sectors closest to the Canal corridor or specific study area (AEE), (Wright et al, 1999), some species of large mammals still remain, such as the white-tailed deer, peccaries,

and howler and white-throated capuchin monkeys; although rare to find in the region close to the city on the Pacific side (Ibáñez et al. 2002).

The terrestrial mammal species potentially present in the area of direct impact (AID) represent over 50% of the mammals recorded in the Country, grouped in 9 orders, 31 families, 97 genus, and 139 species¹. With regards to potential species, CEREB-UP (2005) field studies in the area of direct impact (ADI) of Zones 2 and 5 have confirmed the presence of a total of 47 mammal species, 23 in Zone 2, 39 in Zone 5, and 15 species observed in these two zones (both sides).

It is worth mentioning that although the deterioration and fragmentation of the landscape in Zone 5 are evident, the diversity of mammal fauna observed in the area of direct impact (AID) is greater in Zone 2, where 23 species were observed, while only 39 species were observed in the Pacific (Annex 3. Terrestrial Fauna– Table 5-A1).

It should also be noted that two (2) of the eight (8) mammal orders contribute 75% of the species recorded within the mastofauna; these orders are represented by bats and rodents. The Chiroptera order represents 81 of these flying species in the area of direct impact (AID) of the Panama Canal Expansion Project – Third Set of Locks (Photos 5-7 to 5-12). These species are subdivided in 7 families, of which the phyllostomidae or leaf-nosed bats registered over 60% of the species (52 species), the emballonuridae or sac-winged bats, and the vespertilionidae or evening bats total 8 species each, thus contributing close to 10% of the bat species in each case. The four remaining families, which correspond to the molossidae or free-tailed bats, plus the mormoopidae or leaf-chinned bats, the noctilionidae or fishing bats, and the thyroptera or sucker-footed bat, as a whole contribute less than 20% of the species.

The rodents (order Rodentia), consist of 25 species distributed in eight (8) families, the most abundant being the rat and mice family (muridae) representing more than half of the species of this group. The spiny rats (echimyidae) represent three (3) species (Photo 5-13); and the heteromyidae or pocket mice, as well as the sciuromorpha or squirrels registered 2 species.

¹ La taxonomía de mamíferos aplicada en este estudio sigue Wilson y Reeder (2005):
<<http://nmmhgoph.si.edu/msw/>>

Three families are represented by one species each: the hydrochaeridae (poncho or capibara, a semi-aquatic species), the dasyproctidae (agoutis or ñeques) , and the agoutidae (pacas or conejos pintados).

The six (6) remaining orders constitute 25% of the mammal species; the carnivores (order Carnívora) contribute with 9% of the species (13) distributed in four (4) families (Photo 5-14). The family with the most diversity is that of the raccoons or mapaches, coatis, cusumbís, onlingos, etc., registering 38% of the species of this order. Los mustelidae (weasels or comadrejas, grisons, or lobos de gallinero, etc.) and the cats or felidae represent three (3) species, while the canidae family (dogs or canines) is only represented by two (2) species.

The representatives of the order Didelphimorphia, which represent the opossums or zarigüeyas, represent 4% of the total of this species (6 species). The family didelphidae or opossums or zarigüeyas, consist of 6 species of this order. The members of this order are characterized by being non-placental mammals such as the marsupials or abdominal pouch. The representatives of the order Pilosa registered four (4) families: the myrmecophagidae or anteaters, with one specie; the cyclopedidae or tapacaras with one specie; the three-toed sloths (bradypodidae); and the two-toed sloths (megalonychidae) consist of only one species each (Photo 5-15). The family dasypodidae or armadillos belong to the order Cingulata and is represented by two (2) species in the area of direct impact (AID).

The monkeys of the order Primates are represented by four (4) species in three (3) families: cebidae (2 species), atelidae, and aotidae (Photo 5-16). There are three (3) species of Artiodactyla or even-toed ungulates, distributed among the cervidoae or deers, 2 species; and the, saínos o peccaris, one specie. The leporidae or brazilian rabbit (conejos muletos) (order Lagomorpha) consists of one species only.

5.5.1.3 Birds

Like in the previous section, in the remote areas within the AEG, such as the Upper Chagres River Watershed as well as the Protected Landscape and Protector Forest of San Lorenzo, the

fauna in general is rather complete and in good condition, as regards to the bird fauna, since active harpy eagle nests have been found (Ibáñez et al., 2002). The bird richness in the AEG includes 650 species (Codit et al., 2001). Although hunting is noticeable in the sectors of the specific study area (AEE) closest to the Canal corridor (Wright et al, 1999), species of game birds such as the crax rubra or pavón and pava rubia can still be found in the areas of San Lorenzo, Soberanía and Barro Colorado. This notwithstanding, four species of macaws as well as the crested eagle have been eradicated from the Canal corridor del Canal (Ibáñez et al., 2002).

The investigations conducted in the specific study area (AEE) and the area of direct impact (AID) of the Panama Canal Expansion Project as regards to the bird fauna reveal the presence of 530 species, 134 of which are migratory, according to documental records (CEREB, 2005). The bird fauna documental records reveal that the mentioned species are included in 20 orders, 69 families and 325 genus. Of the species forecasted by the documental records, the CEREB-UP studies confirmed the presence of 176 species of birds, of which were 14 migratory.

It is worthy of mention that five (5) of the twenty (20) orders forecasted for the bird fauna constitute 78% of the bird species included in the lists for the area of direct impact (AID) of the Panama Canal Expansion Project – Third Set of Locks, and these are the Passeriformes (perching birds), the Charadriiformes (seagulls and jacanas), the Falconiformes (eagles and relatives), the Ciconiformes (herons, ibis, storks, buzzards), and the Apodiformes (swifts and hummingbirds) (Photos 5-17 to 5-22).

Following is a summary of the species richness for each order documented for the area of direct impact:

- The Tinamiformes are represented in the area of direct impact by only one family, the Tinamidae, of which two (2) species have been recorded.
- The duck group, order Anseriformes, includes only the family Anatidae with 6 species.
- The podicipedidae, grebes or diving birds are represented by two (2) species. They belong to the order Podicipediformes, whose individuals have lobed toes without membranes and are excellent divers.

- The order of marine birds known as Procellariiformes, including shearwaters, albatrosses, fulmars and petrels, registers elements included in two (2) families, for a total of five (5) species: three (3) for the storm petrel or Hydrobatidae, 2 for the shearwater family or Procellariidae.
- The order of the pelicans and relatives or Pelecaniformes, conformed by medium to large marine or aquatic birds with large beaks and a massive throat pouch, is represented by five (5) families. The family Suliidae or boobies is represented by three (3) species, and the pelican family (Pelecanidae), the cormorants (Phalacrocoracidae), anhingas or aningas, and frigatebirds or Fregatidae represent one species each.
- The order Ciconiiformes, herons, ibises, storks, and vultures, represent 24 species distributed in four (4) families. Of these four (4) families, the family Ardeidae or herons constitute 70% of the species present (17), while the family Threskiornithinae or ibises and Cathartidae or vultures contain three (3) species each or 13% of the species in this order, and the family Ciconiidae or storks represent only one species or 4%.
- The order Falconiformes, which include the diurnal birds of prey such as eagles and relatives, contain 39 species, distributed in two (2) families: the Accipitridae, which include the eagles, hawks and elanus, which registered 74% of the species, and the Falconidae (falcons and caracaras) constitute the remaining species in this order.
- The order Gruiformes is represented by four (4) families, for a total of thirteen (13) species. The most abundant within this order are the rails or family Rallidae with ten (10) species; the Heliornithidae (finfoots), the Eurypygidae (sunbitterns), and the Aramididae (limpkin) with one species each.
- The order Charadriiformes which includes the seagulls, auklets, jacanas, etc., have fifty (50) species distributed in seven (7) families. The Scolopacidae (sandpipers, tringas, curlews) constitute almost 50% of these species; the seagulls and sea swallows represent almost one third of these species, while the remaining 20% is conformed by Charadriidae or plovers, the Jacanidae or jacanas, the Haematopus or oystercatchers, as well as the Recurvirostridae or stilts.
- The Columbiformes, which include the (solitaires, quail dove, pheasant pigeon) chochas, dodos, pigeons and doves register, according to studies and samplings performed in the

area of direct impact (AID), register a total of twelve (12) species, which are grouped into only one family known as the family Columbidae.

- The order Psittaciformes, represents only one family, the psittacidae, which includes seven (7) species; this is the order that includes parrots, parakeets and relatives.
- The order Cuculiformes, which includes the cuckoos, of the family Cuculidae, includes eleven (11) species in the area of direct impact. These birds are characterized by being arboreal, solitary and furtive.
- With regards to owls and barn owls, of the order Strigiformes, eight (8) species of owls have been recorded, while only one species of barn owl has been recorded in the literature of fauna of the area of direct impact.
- The order Apodiformes, which includes the swifts and hummingbirds, presents 28 species, distributed among two (2) families, the trochilidae or hummingbirds which constitute 79% of the species in the order Apodiformes, and the apodidae or swifts, which contribute with 21% (6 species).
- The order Coraciiformes includes a total of nine (9) species. In the first place of this order are the alcedinidae or kingfishers, with a total of six (6) species; while the momotidae or motmots include only three (3) species.
- The Caprimulgiformes or capachos and nightjars or chotachabras are nocturnal birds, which are distributed in two (2) families, the Caprimulgidae or nighthawks and nightjars, with five (5) species registered, and the Nyctibiidae or potoos with two (2) species.
- The order Piciformes is made up of five (5) families, with a total of nineteen (19) species, with almost 50% made up of Picidae or woodpeckers, with nine (9) species; the Ramphastidae or toucans, and the Bucconidae or puffbirds with four (4) species each; the Galbulidae or jacamars, and the Capitoniidae or barbets with one species each.
- The family Trogonidae or trogons, the only species of the order Trogoniformes, presents five (5) species.
- The order Passeriformes or perching birds, contains 270 species and is the order with the greatest number of species, including 24 families, in the following order of abundance: the flycatchers, **dorales** or tyrants, with 71 species, registered slightly over 25% of the perching bird species; the Parulidae or warblers with 30 species, and the thraupidae or

tanagers with 29 species each contributed with approximately 10% of the species. The antbirds and bataras with 22 species, as well as the Icteridae (**bolseros** and oropendolas) with 19 species represent approximately 8% of the species of perching birds. The twelve (12) remaining families contribute the other third of the perching bird species; these are the Hirundinidae or swallows, the Troglodytidae or wrens, the Emberizidae or sparrows, the Vireonidae; the Dendrocolaptidae or woodcreepers; the Cardinalidae or saltators saltadores and grosbeaks, the Furnariidae or overbirds u hojarasqueros and spinetails, the Turdidae or thrushes, the Pipridae or manakins, the Formicariidae or antbirds, and the Sylviidae or warblers, the Cotingidae or cotingas, the Mimidae or mockingbirds, the Corvidae or magpies, the Bombycillidae or waxwings, the Coerebidae or bananaquits, the Motacillidae or wagtails, the Fringillidae or finches, and the Passeridae or sparrows.

5.5.1.4 Reptiles

It is known that within the AEG, in the Chagres watershed, there are 95 species of reptiles (ANAM 2005; Ibáñez et al., 1995) and the list of reptiles for Canal watershed is being updated (ANAM, 2005). In the sectors closest to the Canal corridor in the specific study area (AEE), although hunting is visible (Wright et al, 1999), there still remain reptile species such as the green iguana, an important food source, cocodriles and babillos or small alligators, which have a valuable skin, as well as different types of boas.

According to documental records, three (3) orders of reptiles inhabit the area of direct impact (AID). The order Squamata which includes snakes, casquehead lizards or merachos, geckos, iguanas and allies, represent 79% of the families in this class; these 11 families present 48 species registered for the area of direct impact (AID) of the expansion project (Photos 5-23 through 5-26). Fifteen (15) of these species are Colubridae (snakes), nine (9) are Polychrotidae (anole lizards), six (6) species are geckos or limpiacasas, four (4) are borrigueros, three (3) are Viperidae or vipers, while the iguanas, the Gymnophthalmidae, the coral snakes, the Corytophanidae (casquehead lizards or merachos), and the boas are made of two (2) species each, and the Scincidae or skins of only one species. The turtles, of the order Testudines, consists of four (4) species belonging to four (4) families, the Chelydridae, the Emydidae, the

Geoemydidae, and the Kinosternidae. The alligators (Alligatoridae) and the crocodiles (Crocodylidae) have one species each and belong to the order Crocodylia. The study conducted by CEREB-UP (2005) confirmed the presence of 38 reptile species within the (AID).

5.5.1.5 Amphibians

There are 93 species of amphibians known in the AEG; this represents over 50% of the amphibians known in the Country (Condit et al., 2001). Most of the amphibian species known in the AEG inhabit the forests and are associated to forest environments; there are very few which exclusively inhabit open areas such as grasslands (7 species); however, there is a greater segregation with regards to their occupation of highland and lowland areas or both (Ibáñez et al., 2002).

Two (2) orders of amphibians have been documented in the specific study area (AEE) and the area of direct impact (AID), with the order Anura, frogs and toads, the most abundant, with 42 species distributed in nine (9) families (Photos de la 5-27 a la 5-29). The tree frogs of the family Hylidae total 14 species; the Brachycephalidae include 9 species; the neotropical frogs of the family Leptodactylidae register five (5) species; the glass frogs (Centrolenidae) include four (4) species, the poison-dart frogs (Dendrobatidae) and the true toads (Bufonidae) present three (3) species each; the true frogs (Ranidae) register two (2) species, and the narrow-mouthed toads (Microhylidae) and the túngara frogs (Leiuperidae) only register one specie in each family.

The order Caudata which comprises the salamanders, with only one family in Panama, the Plethodontidae or lungless salamander) and only one specie within the area of direct impact (AID), recorded solely in the Atlantic side. The CEREB-UP studies conducted specially within the area of direct impact (AID) confirmed the existence of 32 amphian species.

5.5.1.6 Terrestrial Invertebrates

The studies on terrestrial invertebrates conducted in the Canal watershed have focused mainly on those groups of medicinal importance and more recently those of agricultural and forestal importance (ANCON, 1995). Navas et al. (1995) emphasize that within the specific study area (AEE) there is a high degree of diversity of beneficial insects, or natural enemies, with a total of 56 families, especially of the Order Hymenoptera (wasps, ants and bees) which comprise over 55% of the families. The researches collected a total of 138,184 insect samples belonging to the taxonomic groups of medical interest. These insects correspond mainly to the order Diptera which comprises flies and mosquitoes. The following eight (8) families had the highest representation: Culicidae or mosquitoes (14,575 specimens, 14 genus and 19 species), Psychodidae or sand flies (1,346 specimens, two genus and 18 species), Ceratopogonidae or biting midges or jejenes (14,383 specimens, especially of the genus *Culicoides* 43 species), Calliphoridae (21,908 specimens genus *Chrysomya* for the most part), Muscidae (12, 944 specimens), Sarcophagidae (9,712 specimens) and Tabanidae (55 specimens). Also collected were 28,093 Formicidae (ants), 10,134 Staphylinidae, 1,292 Apoidea, 177 Vespoidea, and 103 Blattidae. In addition to the insects, arachnids were also collected, among them 23, 462 specimens of mites (Acari). Navas et al. (1995) also indicates that the Drosophilidae in particular was the predominant family, considering that all taxa capturados and the less frequent families included the Masaridae and Ropronidae (Hymenoptera), Dilaridae (Neuroptera), Othniidae (Coleoptera) and Strongylophthalmiidae (Diptera).

The researchers also indicate that the presence of species of insects of forestal and agricultural importance was not very noticeable; however, these were recorded during the collection seasons. Members of the following orders were found among these groups: Coleoptera (beetles, weevils, fireflies: Families Cerambycidae, Buprestidae, Curculionidae, Scolytidae, Chrysomellidae), Lepidopteras (butterflies and moths: Families Noctuidae, Pyralidae, Gelechiidae), the Homeopteras (aphids, scales, whiteflies: Familias: Aphididae, Cicadellidae, Delphacidae, Ceropidae); Diptera (flies and mosquitoes; Familias: Tephritidae, Agromyzidae, Cecidomyiidae).

It is worth mentioning that the highest diversity and greatest index of equitability index of insects in the family Culicidae, genus Culicoides, was found in the Paraiso townside, located between Zone 4 and Zone 5, and that the highest number of species of the family Psychodidae as well as the highest number of individuals collected (Navas et al, 1995) were found in Gamboa, Zone 3. It is important to clarify that in the studies conducted there are no special references for the area of direct impact (AID); however, part of the sampling stations established in Paraiso are bounded by the area of direct impact (AID) between Zones 4 and 5 entre las zonas 4 y 5.

5.5.1.7 Diversity of Terrestrial Vertebrates by Type of Habitat

ANCON-TNC Studies

Upon comparing the data presented in the study conducted by the group ANCON – TNC (1996 a,b), shown in Table 5-26, distribution patterns typical of the fauna of the specific study area stand out, for example, it is easily noted that birds constitute the most diverse group, of which resident species surpass the migratory species by a wide margin. The number of species in the bird group present in the region studied on the Atlantic side, in the sector of Protected Landscape and Protector Forest of San Lorenzo, is slightly higher than those of the group in the areas studied on the Pacific side. Within the bird group, there is a higher diversity in the types of vegetation of the evergreen forests or semievergreen forests (high, mixed and low); followed by the tropic semideciduous tropical lowland forests (high, mixed and low).

The tropical semideciduous lowland forests, mixed and low, shelter a high specific diversity, probably because of its superior superficial cover; followed in order of abundance the mixed evergreen forest. The salt marshes and certain wet forests, such as the cativo and palm forests, include the types of vegetation with less diversity of bird species. There is lesser abundance of mammal fauna, and those with the highest diversity of this group are the evergreen and semideciduous forests. The salt water marshes and flooded palm forest are those with the least diversity.

Table 5-26**Diversity of Terrestrial Vertebrate Fauna by Type of Vegetation in the Specific Study Area (AEE) of the Panama Canal Expansion Project**

Hábitat	Birds			Mammals	Reptiles	Amphibians	Total Vertebrate Species
	Migratorys	Residents	Total				
High Evergreen Forest	4	67	71	23	6	10	110
Mixed Evergreen Forest	8	103	111	40	15	11	177
Low Evergreen Forest	3	81	84	23	9	8	124
High Semideciduos Forest	7	49	56	18	6	4	84
Mixed Semideciduos Forest	21	154	175	62	26	28	291
Low Semideciduos Forest	30	178	208	60	18	18	304
Deciduos Forest	25	93	118	35	7	0	160
Cativo Forest	2	54	56	25	10	8	99
Flooded Palm Forest	0	39	39	5	5	9	58
Mangrove Forest	27	120	147	27	4	0	178
Shrubs	18	59	77	17	4	0	98
Salt Marsh	6	54	60	2	4	8	74
Grassland	17	86	103	5	7	2	117
Total of Species by Taxonomic Group	67	370	437	113	54	48	652

Source: URS Holdings, Inc. Based on data by the Asociación Nacional para la Conservación de la Naturaleza (ANCON) and The Nature Conservancy (TNC) – Panamá, 1996 a, b.

In the case of reptiles, the mixed, evergreen, and semideciduos forests presented the highest diversity, comparable to that of the cativo forests. The reptile group is less diverse in the underbrushed, shrublands, salt marshes, and mangrove forests. The amphibian is the less diverse group, with a noticeable diversity only in the evergreen and semideciduos forests, and more scarce in the wetlands.

5.5.2 Aquatic Fauna

The Panama Canal, because of the way it is structured: Atlantic marine area, fresh water mirror, which includes Gatun Lake, as well as several tributaries, among which the Chagres River is the most important, Miraflores Lake, a brackish water body; and finally, the Pacific marine area, has

supported the development of a high aquatic biodiversity. This is comprised of Atlantic marine species capable of migrating toward fresh water bodies (Photo 5-30), native fresh water species (Photo 5-31) and introduced fresh water species (Photo 5-32), and Pacific marine species (Photo 5-33), capable of migrating to fresh water bodies (FACINET/CCML-ACP 2004 and 2005).

A wide variety of studies conducted in the past few years name the different components of the aquatic fauna of the Panam Canal system (ACP 2006, PB Consult 2006, CEREB 2005, FACINET/CCML-ACP 2004 and 2005; The Luis Berger Group, Inc. 2004a 2004b 2004c 2004d, URS Holdings, Inc. 2004, CEREB 2003), which were preceded by the vast study of the Panama Canal Biological Inventory, with its different components (D’Croz et al. 1994, Gutiérrez et al. 1995, Ibáñez et al. 1995, Smith 1995), prepared by the Universidad de Panamá-ANCON. It is worth mentioning that to become acquainted with previous studies conducted in the Environmental Study Area (ESA), relative to the different aspects of the aquatic fauna, a review of the studies by CEREB 2005, FACINET/CCML-ACP 2004 and 2005 and CEREB 2003 is recommended.

By consolidating the information contained in the principal studies mentioned in the previous paragraph and maintaining a structure similar to that of the lists presented (URS Holdings, Inc. 2004), seven tables were prepared: Annex 3 – Aquatic Fauna Table 5-A2, 5-A4 through 5-A9, which presents a general list of the aquatic fauna, from Zone 1 (Atlantic Coast) through Zone 6 (Pacific Coast) and Annexes 3- Aquatic Fauna Tabla 5-A4 through 5-A9, which present a general list of the fauna, with special attention to the zone where the different organisms are found, from Zone 1 through Zone 6 .

Fish

Marine fish dominate in the Atlantic and Pacific areas; however, the presence of certain marine species capable of migrating through the locks towards brackish waters such as those in Miraflores Lake and fresh water such as those of Gatun Lake, are observed. Table No.5-27 summarizes the number of species of marine fish observed in Gatun and Miraflores lakes (FACINET/CCML.ACP 2004 and 2005), which make evident that the presence of marine

species in the lakes is due to seasonal migrations. The marine species in both lakes correspond for the most part to the closest marine geographical area. The total list marine fish species collected by lake can be seen in Annex 3 – Aquatic Fauna Table 5-A3.

Table 5-27

Preliminary Assessment of Marine Fish Species Present in Gatun and Miraflores Lakes

U.P. Studies	Gatun Lake			Miraflores Lake			Both Lakes		
	T.E.M.	E.C.	E.E.	T.E.M.	E.C.	E.E.	T.E.M.A.	T.E.C.	T.E.D.
2004-2005	21	3	18	22*	5*	17	33*	10*	23

Source: FACINET/CCML-ACP 2004 y 2005

T.E.M.: Total Marine Species

E.C.: Common Species (present in both gatherings, 2004 y 2005)

E.E.: Seasonal Species (present in one gathering, 2004 o 2005)

T.E.M.A: Total of Both Maine Species

T.E.C.: Total of Common Species (present in both lakes)

T.E.D.: Total of Different Species (present in one lake)

* The tarpon (sábalo real), although not collected, was included because of its wide distribution.

As expected with regards to fresh water fish, these dominate the fresh water sectors in number and variety, and the presence of native species and introduced species is observed (FACINET/CCML.ACP 2004 and 2005).

Invertebrates

The specific study area (AEE) and the area of direct impact (AID) show, as a whole, an excellent development of aquatic invertebrates, with a great biodiversity, and the presence of marine, brackish, and fresh water species. Among these, the presence of certain introduced species and species probably associated to the locks operations can also be observed.

Other Groups

The coral development, as expected, is exclusive to the Canal marine terminals, with a higher diversity in the Atlantic area. Finally included are: one marina mamal (the manatee), two (2) crocodile specie (small crocodile or babillo and the american cocordile or cocodrilo aguja), and three (3) species of aquatec turtles (alligator turtle, freshwater turtle or jicotea and yellow turtle).

5.5.3 Characterization of Fauna by Zone (Specific Study Area and Area of Direct Impact)

5.5.3.1 Atlantic Coast (Zone 1)

TERRESTRIAL FAUNA

Zone 1, the Atlantic Coast, of the natural environment in the Preliminary Environmental Assessment (ACP, 2006g), includes the coastal sectors adjoining Limón Bay, including part of the San Lorenzo Protected Landscape and Protector Forest, the former Fort Sherman, Borracho Hill, and the Tanque Negro area closests to Telfers Island, the city of Colon, and the Galeta Island Protected Landscape (Figure 5-6).

The main study on the biodiversity of Zone 1 was conducted in 1996 by ANCON and TNC (1996a) in lands then under the administration of the United States Department of Defense. This study considered the territories known as Fort Sherman and the Piña Firing Range west of the Canal, and the Galeta Island Navy Security Area east of Limon Bay.

In general terms, the Atlantic coas tarea belonging to the Project's specific study area (AEE) includes seven (7) types of general habitats: deciduous forest, semideciduous tropical forest, seasonal evergreen forest, seasonally-flooded evergreen forest (cativo forest), semi-permanently flooded evergreen florest (palm forest), mangrove forest, and semi-natural flooded tropical grassland.

The area proposed as a disposal zone for dredged material west of the Canal corresponds exactly to the area identified by ANCON-TNC as a semi-natural flooded tropical grassland, and which

has been utilized for several purposes, such as parachute jumping practices (ANCON-TNC 1996 b).

The mixed semideciduous forest towards the east registered 22 mammal species, including eleven (11) bats, one (1) opossum, three (3) rodents, three (3) monkey species, two (2) carnivores, and two (2) sloths. Also registered were 47 bird species, of which 46 are resident species and one is a migratory specie. Four (4) amphibian species and one (1) reptile species were recorded.

The lowland semideciduous forest, which extends between the Morito creek, Borracho Hill and the flooded forests adjacent to the Chagres River, recorded 66 bird species, 22 mamal species, including 11 bats, 2 carnivores, 3 rodents, 2 monkeys, one deer, and 3 opossums. The presence of 2 reptile species and 2 amphibian species was also verified.

The deciduous forest or caducifolia, which extends to the east, bordering Limón Bay, boasts 20 mammal species including 10 bats, 3 rodents, 2 opossums, 2 edentate, 1 ungulate, 2 monkeys, and one 1 carnivore; in addition, 73 bird species, 65 resident and 8 migratory, were observed. Three (3) reptile species are also present, but no amphibian species were observed.

The cativo forest is located mostly along the bank of the Chagres River and between the Mojinga swamp and the Morito creek. There are also small patches of cativo forest south of the deciduous forest and between this and Gatun Road (S2). Twenty-two (22) mamal species have been observed in this habitat; also present here are 56 bird species, 2 of which are migratory, as well as 10 reptile species, and 8 amphibian species.

In the flooded palm forest extending along the northeast and northwest banks of the Mojinga swamp, cohabit 5 mammal species; 39 bird species, all of which are resident species; 5 reptile species, and 9 amphibian species.

The mangrove forest extends in 2 wide patches of vegetation along the coast of Limón Bay and the mouths of the Petitpie and Aguadulce rivers. Twelve (12) mammal species have been found

in this habitat, including 11 bats, 1 carnivore; 58 bird species, 9 migratory and 49 resident species; in addition, 3 reptile species have been observed.

The type of vegetation known as shrubland is located at both sides of Gatun Road, between the Morito creek and the Petitpie river, east of the Mojinga swamp. It consists of dense shrublands comprised of *Gynerium sacharoides* (cañabrava), paja blanca or Vietnamita, and wild cane. This hábitat is difficult to penetrate hinders the sampling of fauna, therefore, among the mammals, only one (1) carnivore and two (2) rodents, plus one reptile species have been recorded.

The following Table 5-28 presents a summary of the vertebrate fauna identified by ANCON-TNC (1996b) in the former military installations of Fort Sherman, the Piña Firing Range, and the Galeta Island Navy Security Area.

Table 5-28
Diversity by Vertebrate Species Recorded, by Type of Vegetation, in the Former Military Installations in the Atlantic Coast (Zone 1)

Types of Vegetation	Taxa						Total Fauna
	Mammals	Aves			Reptiles	Amphibians	
		Migratory	Residents	Totals			
Mixed Semideciduous Forest	22	1	46	47	1	4	74
Lowland Semideciduous Forest	22	6	60	66	2	2	93
Deciduous Forest	25	8	65	73	3	4	96
Cativo Forest	25	2	54	56	10	8	99
Mangrove Forest	12	9	49	58	3	0	73
Flooded Shrubs	0	-	-	0	1	0	1
Flooded Semi-natural Grassland	1	5	35	40	1	0	42

Types of Vegetation	Taxa					Total Fauna	
	Mammals	Aves			Reptiles		Amphibians
		Migratory	Residents	Totals			
Totals*	60	24	189	213	27	26	325

- Indicates that this hábitat has been sampled for birds.

*Includes 12 types of vegetation identified by ANCON-TNC (1996b)

Source: ANCON-TNC (1996b).

As regards to the entomofauna in the environments in this Zone, although there are no articular references to cite, it is important to mention that the entomofauna in different strata of the forest is being currently studied by researchers associated to the Smithsonian Institute, by means of the construction crane located in the San Lorenzo Protected Landscape.

AQUATIC FAUNA

The aquatic fauna that could be associated to the Atlantic Coast or Zone 1 is comprised mostly by marine fish totalling some one hundred and sixty (160) species (see Annex 3 – Aquatic Fauna Table 5-A4). In this Zone, where there is a preponderance of marine characteristics, according to studies conducted, some freshwater species are also represented, either because of their high capacity to resist changing variations in the Zone or because they have been recorded in rivers flowing into the Atlantic. In addition, Zone 1 also has a vast variety of aquatic invertebrates (137 species reported in the studies) among which are: the Crustacea, represented by fifty-seven (57) different species (including 11 planktonic crustaceans), the bivalve mollusks and the gasteropoda which contribute with thirty-six (36) species, and the echinoderms with twenty (20). The variety of coral species reported total seventy-two (72), condition typical of the Atlantic side given the high diversity of these organisms in the Zone. Also mentioned in this Zone is the presence of two (2) superior predators: the babillo (*Caiman crocodilus fuscus*) and the crocodile (*Crocodylus acutus*), mentioned in section A-1 of CITES. The complete list of aquatic species documented in the revised studies is included in Annex 3 – Aquatic Fauna Table 5-A4.

5.5.3.2 Gatun Locks (Zone 2)

TERRESTRIALE FAUNA

The ACP (2006) study identifies the area of Gatun Locks as Zone 2, which encompasses an area of 7.5 Km² where the existing locks system is located, as well as the 1939 excavation area (presently covered by small lakes and secondary forests), and coincides with the alignment of the proposed third set of locks. The former Fort Davis, now the José Dominador Bazán residential area, and areas of secondary forest are located here (Figure 5-6).

Within this Zone are also areas kept free of vegetation due to Canal operations. According to the CEREB – UP (2005) study, there are seven types of vegetation in this Zone: mature secondary forests, intermediate secondary forests, gallery forests, wetlands, shrubs, and grasslands. The forests represent 36% of the total surface, while the shrubs and grasslands represent 34% (Figure 5-6). The greatest diversity of species of mastozoologic fauna within Zone 2, was found in the environment of the mature secondary forest (Table 5-29).

Table 5-29

Diversity of Mammal Groups, by Types of Vegetation, in the Specific Study Area (AEE) of Gatun Locks (Zone 2)

Type of Vegetation	Orders	Families	Species
Mature Secondary Forest	6	12	18
Intermediate Secondary Forest	6	8	12
Shrubs	4	6	6
Grassland	2	3	3
Totals	6	14	24

Source: CEREB – UP, 2005

As regards to mammals, the CEREB-UP (2005) study recorded a total of 23 species in the area of direct impact (AID) in Zone 2. The mature secondary forest presented 18 species, distributed as follows: 6 bats, 3 carnivore species as well as primates and pilosa (anteaters and sloths), 2 rodent species and one (1) armadillo species. Among the most common mammals are the giant-

fruit eating bat, the sloths, the coati or cusumbí and the spiny rat. Twelve (12) mammal species including four (4) bats, two (2) species each of carnivores, primates and rodents and one (1) species each of anteaters and armadillos were recorded in the secondary forest. Six (6) mammal species were recorded in the shrubs and three (3) in the grassland.

With regards to birds in the area of Gatun Locks (Zone 2), it was confirmed that the mature secondary forest includes the highest number of species, but also includes the lowest number of migratory species (Table 5-30).

Table 5-30
Abundance of Bird Groups, by Type of Vegetation in the Specific Study Area (AEE) of Gatun Locks (Zone 2)

Type of Vegetation	Orders	Families	Species	Migratory
Mature Secondary Forest	8	24	44	1
Grassland	10	21	42	2
Intermediate Secondary Forest	6	19	36	1
Shrubs	9	19	35	3

Source: CEREB – UP, 2005

The mature secondary forest is the habitat with the greatest diversity and abundance in the Gatun Locks zone (Table 5-31). With regards to reptiles, the mature secondary forests shelters two (2) orders, seven (7) families, eleven (11) genus, and twelve (12) species, especially polychrotid lizards and colubridae. There are five (5) families, twelve (12) genus, and twenty (20) species of amphibians.

Table 5-31
Abundance of Reptile and Amphibian Groups, by Type of Vegetation in the Specific Study Area (AEE) of Gatun Locks (Zone 2)

Tiype of Vegetation	Orders	Families	Species
Mature Secondary Forest	3	12	32
Grassland	3	8	9
Wetland Forest	3	8	8
Intermediate Secondary Fores	2	5	6
Body of Water / Mirror of water	2	3	3
Shrubs	1	1	1

Source: CEREB – UP, 2005

Representatives of five (5) families, four (4) genus, and four (4) species of reptiles have been found in the grasslands, as well as three (3) families, four (4) genus, and four (4) species of amphibians. Five (5) families, five (5) genus, and five (5) species of reptiles are found in the wetland forest, and three (3) families, three (3) genus, and three (3) species of amphibians were recorded.

With regards to the area of direct impact (AID) of Zone 2, La Tabla 5- 32 shows a potential diversity of vertebrate species in comparison with the diversity of vertebrate species observed according to CEREB-UP (2005).

Table 5-32
Potential Diversity of Vertebrate Species in the Area of Direct Impact (AID) versus the
Richness of Vertebrate Species
Observed (Zone 2)

TAXA	Expected Species	Oserved Species
Mamals	133	23
Birds	503	99
Reptiles	31	25
Amphibians	30	24
Totals	697	171

Source: CEREB-UP (2005)

Taking into consideration the mobility of most of the species of fauna reported for the specific study area (AEE), it is expected that part of the fauna reported for the area of direct impact (AID) repeats itself in similar environments. Hoever,the areas of particular impact correspond to fairly

altered sectors as a result of repetitive maintenance works and the development of the interoceanic waterway.

AQUATIC FAUNA

The revised studies suggest the presence of 35 fish species and 16 species of crustaceans and mollusks in the specific study area (AEE) and the area of direct impact (AID) in Zone 2. One reptile, the babillo, has been reported in this Zone. The complete list of aquatic species collected for the revised studies are presented in Annex 3 – Aquatic Fauna Table 5-A6.

The ichthyological samples collected by CEREB-UP (2005) in Zone 2 mostly present freshwater species with 17 freshwater species and only two (2) marine species reported for the Zone. CEREB-UP (2005) recorded eleven (11) invertebrate species, the most important being the crustaceos decapodos, although the presence of mollusks bivalves is also recorded. Tables 5-33 and 5-36 present a summary of CEREB-UP (2005) data. It can be noted the richness of the aquatic fauna in rivers and creeks with relation to 1939 excavation.

Table 5-33

Richness of Taxa and Species of Vertebrate Aquatic Fauna Verified in the Field in the Water Bodies Sampled in the Area of Direct Impact in Zone 2

Class	Orders	Families	Species
Fish	5	10	19
Crustaceans	1	3	8
Mollusks	2	3	3
Total	8	16	30

Source: URS Holdings, Inc. baed on CEREB-UP (2005) information.

Table 5-34

**Richness of Taxa and Species of Aquatic Fish and Macroinvertebrates
Collected in the Water Bodies Sampled in the Area of Direct Impact (AID) of Zone 2**

Water Body	Orders	Families	Species
1939 Excavation (L-3)	5	9	14
Rivers and Streams	8	12	22
Total	8	16	30

Source: URS Holdings, Inc. based on CEREB-UP (2005) information.

Table 5-35

**Richness of Taxa and Fish Species Recorded on the Field in Water Bodies Sampled in
Zone 2**

Water Bodies	Orders	Families	Species
1939 Excavation (L-3)	3	6	8
Rivers and Streams	7	7	14
Total	5	10	19

Source: URS Holdings, Inc. based on CEREB-UP (2005) information.

Table 5-36

**Richness of Taxa and Species of Crustaceans and Mollusks Recorded on the Field in the
Water Bodies Sampled in Zone 2**

Water Bodies	Orders	Families	Species
1939 Excavation (L-3)	2	3	6
Rivers and Streams	3	5	8
Total	3	5	11

Source: URS Holdings, Inc. based CEREB-UP (2005) information.

5.5.3.3 Gatun Lake (Zone 3)

TERRESTRIAL FAUNA

According to the ACP (2006n) study, the Gatun Lake sector (Zone 3), comprehend secondary forests in several stages of human intervention, shrublands, grassland and cultivated areas mostly located southeast of the lake.

The Gatun Lake fauna has been study, especially in the Barro Colorado Island National Monument and in the Soberanía National Park. However, there are no specific studies of the entire perimeter of Gatun Lake. The area of direct impact within Zone 3 includes the entire bank of the lake due to the height increment of the elevation of approximately 45 cm of the water mirror. The construction, excavation, and dredging activities will not affect the land areas in Zone 3.

There are records on the diversity of insects of medical importance in Zone 3, almost bordering with one 4, especially of the Gamboa sectors (stations G1, G2, G3, G4) and towards the southeastern end of Gatun Lake in La Arenosa (Are 1, Are 2, Are 3) (Figure 5-6). Both Gamboa and La Arenosa are on the Atlantic side of the watershed, beside Gatun Lake, have relatively well inhabited environments. Gamboa has adjoining forest sectors while La Arenosa includes mainly lands used for agricultural and livestock farming.

Records for these sectores emphasize the families Culicidae (mosquitoes) and Psychodidae (las chitras); and among the Culicidae the genus *Culex*, *Anopheles*, *Aedes*, *Culicoides*, *Mansonia* (Navas et al., 1995). In general, the Culicidae are seasonal, diminishing in number in the dry season. The genus *Culex*, which predominated in all the simple locations, including La Arenosa and Gamboa; the *Culex* is capable of transmitting the filarosis and the encephalitis virus. The genus *Anopheles* is especially important for its potential to transmit malaria, and the *Aedes* and the *Mansonia* have the potential to transmit the Venezuelan equine encephalitis. As regards to insects of the family Psychodidae, Gamboa presented the largest number of species as well as collected individuals, including 12 of the 16 *Lutzomia* species found in the study.

AQUATIC FAUNA

The freshwater conditions predominant in Gatun lake or Zone 3 show the presence of fifty-five (55) different freshwater fish species, this being the largest number as regards to diversity of freshwater species throughout the Canal. The fifteen (15) species of marine fish reported for Gatun lake organisms capable of migrating, and a few can adapt to this type of conditions, that is, they can tolerate significant changes in the salinity of the water. Thus, here we find species such as the tarpon (*Megalops atlanticus* Valenciennes, 1847), the fat snooks (*Centropomus parallelus* Poey, 1860; *C. viridis* Lockington, 1877 and *C. armatus* Gill, 1863), and the mojarra (*Gerres cinereus*, Walbaum, 1792), among others. The invertebrates reported belong mostly to the gastropod mollusks and decapods crustaceans. Of the fifty-six (56) invertebrates reported, twenty-six (26) correspond to planktonic crustaceans, dominated by cladocerans and copepods, characteristics of freshwater environments, such as that of Gatun Lake.

The typical characteristics of the lake allow larger predators to be present in this Zone, such as the babillo and three (3) turtle species: the snapping turtle (*Chelydra acutirostris*), the white-tipped mud turtle tortuga amarilla (*Kinosternon leucostomum*) and the jicotea (*Trachemys scripta*).

The largest aquatic animal in Zona 4 is the manatee (*Trichechus manatus*), a fully aquatic herbivorous mammal introduced to Gatun Lake to control the aquatic vegetation. The complete list of aquatic species documented by the revised studies is presented in Annex 3 – Aquatic Fauna Table 5-A6.

5.5.3.4 Culebra Cut (Zone 4)

TERRESTRIAL FAUNA

This is the area of the waterway extending from the mouth of the Chagres River in Gamboa to the townsite of Paraíso, including Bas Obispo Reach and the Empire Reach. The vegetation in the Zone includes the following habitats: grasslands on both sides of the waterway, mature forest in the northeaster sector, and isolated patches of the same forest in the southeastern sector, and secondary forest throughout the entire land area alongside the waterway (Figura 5-7).

The study of the former Empire Range conducted by ANCON-TNC (1996a) covered a large part of the western sector of Zone 4, without including the Canal zone. It is important to emphasize that the ANCON-TNC study corroborates that the former Empire Range zone, as well as the HOROKO Complex in Zone 6, are under heavy hunting pressure, especially on weekends.

Twenty (20) species of bats, six (6) species of rodents, two (2) species of monkey, two (2) species of anteaters, two (2) species of carnivores, one (1) species of opossum, and one (1) species of armadillo were sampled in the semideciduous lowland forest, the most extensive and most perturbed type of vegetation in the area. As regards to amphibians and reptiles of this habitat, twelve (12) species amphibians and eleven (11) species of reptiles were collected.

A total of 101 birds, 17 of which are migratory (Table 5-37) were recorded in areas of the mixed semideciduous forest of the former Empire Firing Range. The ANCON – TNC (1996 a) study indicates that there has been a noticeable decline among the populations of seven (7) of the seventeen (17) migratory species typical of the area; these are: *Dendroica castanea* (la reinita pechicastaña), *Wilsonia canadensis* (la reinita collareja), *Oporornis formoso* (la reinita cachetinegra), *Pheucticus ludovicianus* (picogruoso pechirrosado), *Contopus virens* (el pibí oriental), *Protonotaria citrea* (la reinita protonotaria) and the *Hylocichla mustelina* (el zorzal del bosque).

Table 5-37
Diversity of Species Recorded by Type of
Vegetation in the Former Empire Firing Range

Types of Vegetation	Taxa					Total Fauna	
	Mammals	Birds			Reptiles		Amphibians
		Migratory	Resident	Totals			
Mixed Semideciduous Forest	29	17	84	101	15	15	162
Lowland Semideciduous Forest	34	20	107	127	11	12	184
Grassland	2	2	19	21	4	0	26
Total	41	23	122	145	19	17	223

Source: ANCON – TNC, 1996 a

Only two (2) mammals, the spiny rat (*Proechymis semispinosus*) and the hispic cotton rat (*Sigmodon hispidus*) were collected in the grasslands. The record of bird species includes a total of 21 species, including two (2) migratory, of which the eastern wood-pewee (*Contopus virens*) shows a significant decline in its pulation. Only four (4) reptile species have been recorded in this Zone, including the neotropical bird snake (*Pseustes poecilonotus*) and the Mexican vine snake (*Oxybelis aeneus*), which has one of the widest distribution of the neotropical snakes. The absence of amphibians in this habitat could be attributed to the absence of permanent water bodies or to low humidity (ANCON – TNC, 1996 a).

There are also registers of insects present in this Zone, based on information generated by Navas et al. (1995) in one of the Paraiso sampling stations (P1) and on the the Arraijan stations (A3); in addition, the Paraiso P2 station borders Zone 5 (Figure 5-7). Furthermore, as pointed out in the previous section, the stations used in Gamboa border this Zone at the northern end.

The cited study indicates that Paraiso presented the highest diversity and equitabiliby of the species in the Family Culicidae; in addition, it also registered a significant number of species of

the Family Culicoides, with the following six dominant species: *C. insignis*, *C. furens*, *C. diabolicus*, *C. pseudodiabolicus*, *C. leoldoi* and *C. hyla*. The Psychodidae include the genus *Lutzomia*, which is recorded as the transmitter of the cutaneous leishmaniasis with seven (7) species, the greatest diversity of Culicidae (6 species) was also recorded in Paraiso.

Aquatic samples (Figure 5-7) used to identify insects in the hojarasca and vegetal residues were taken at the townsite of Arraijan, A3. The orders Ephemeroptera, Odonata, and Trichoptera were present in all the sections recording this type of samples; where the Odonatos did not seem to be affected by seasonal variations.

AQUATIC FAUNA

The revised studies suggest a low diversity of fish in the Canal waters in Zone 4, with only three (3) freshwater fish species and one marine species, the tarpon (*Megalops atlanticus*) (see Annex 3 - Table 5-A7). The largest fish among the freshwater fish is the peacock bass (*Cichla monoculus*), a species introduced in the Panama canal and voracious predator of smaller fishes. Another important predator in the aquatic ecosystem of Zone 4 in the Canal is the **babillo**, reaching a large size in this Zone. The presence of manatees (*Trichechus manatus* Linnaeus, 1758) has been reported in this Zone. The presence of species of large predators and manatees suggest a healthy ecosystem in spite of the scarce data on fish species. The complete list of aquatic species documented in the revised studies is presented in Annex 3 – Aquatic Fauna Table 5-A7.

5.5.9.5 Pacific Locks (Zone 5)

TERRESTRIAL FAUNA

Zone 5 or the Pacific Locks area, covers the territory between Luisa Hill and Paraíso Hill, to the former Cocolí townsite and the West Corozal installations, including east side of the Canal, the townsites of Pedro Miguel, Pedro Miguel locks, Brazo Camaran, the mouth of the Caimitillo River, Miraflores locks, Cocoli Hill, Aguadulce Hill, the North Lagoon, the South Lagoon,

mouth of the Cocoli arm, area of highway K2 or Borinquen, and part of the area drained by the southern arm of the Grande River (Figure 5-7).

This Zone includes various types of vegetation; from a highly intervened lowland secondary forest, large areas of freshwater grasslands and wetlands, and mangrove forests; the inhabited and industrial areas extend noticeably into this Zone, such as the former Cocoli townsite, ACP installations in Corozal West, and the industrial area in front of the former Fort Clayton. There are also two excavations in the area, known as the North Lagoon and South Lagoon, which correspond to excavations performed in 1939 and later abandoned. Tables 5-38 through 5-41 present a summary of the data pertaining to Zone 5 included in the CEREB-UP (2005) study.

Table 5-38
Diversity of Mammals by Types of Vegetation in the
en el Area of Direct Impact of the Pacific Locks (Zone 5)

Type of Vegetation	Orders	Families	Species
Mature Secondary Forest	9	21	30
Intermediate Secondary Forest	4	6	9
Mangrove Forest	2	3	4
Shrublands	5	8	10
Grasslands	3	9	9
Totals	9	21	39

Source: CEREB – UP, 2005

Table 5-39
Diversity of Bird Fauna Groups by Type of Vegetation in the Area of Direct Impact in the
Pacific Locks (Zone 5)

Type of Vegetation	Orders	Families	Species	Migratory
Maduro Secondary Forest	9	23	51	2
Intermediate Secondary Forest	10	19	36	3
Wetland Forest	12	27	54	0
Mangrove Forest	13	27	60	6

Type of Vegetation	Orders	Families	Species	Migratory
Underbrush	9	19	35	3
Shrublands	15	30	63	2
Water Mirror	2	4	4	0
Totals	19	48	143	10

Source: CEREB – UP, 2005

Table 5-40
Diversity of Reptile Groups by Typo of Vegetation in the Area of Direct Impact in the Pacific Locks (Zone 5)

Type of Vegetation	Orders	Families	Species
Mature Secondary Forest	1	6	4
Intermediate Secondary Forest	1	2	2
Wetland Forest	2	3	3
Mangrove	1	3	4
Shrublands	1	2	3
Grasslands	2	8	13
Water Mirror	3	3	3
Totals	3	11	32

Source: CEREB – UP, 2005

Table 5-41

Diversity of Amphibian Groups by Type of Vegetation in the Area of Direct Impact in the Pacific Locks (Zone 5)

Type of Vegetation	Orders	Families	Species
Mature Secondary Forest	1	8	20
Intermediate Secondary Forest	1	4	5
Westland Forest	1	1	1
Mangrove Forest	0	0	0
Shrubland	0	0	0
Grassland	1	5	12
Water Mirror	0	0	0
Totals	1	8	27

Source: CEREB – UP, 2005

As regards to the Area of Direct Impact in Zone 5 specifically, Table 5-42, summarizes the diversity of expected vertebrate species in the Area of Direct Impact, and provides a comparison with the richness of vertebrate species observed in that particular sector.

Table 5-42

Potential Diversity of Vertebrate Species in the Area of Direct Impact (ADI) versus the Richness of Vertebrate Species Observed (Zone 5)

TAXA	Expected Species	Observed Species
Mammals	131	39
Birds	455	143
Reptiles	43	32
Amphibians	35	27
Totals	664	241

Source: CEREB – UP, 2005

As regards to the insects in this sector, within Zone 5, the insect collection stations utilized by Navas et al (1996) in Paraiso (P2 and P3) were considered; in addition, station P1, located in the

sector adjoining this Zone, and on station in Arrraijan, the A2, which is relatively close, were used as reference. Paraiso presented the lesser number of specimens per collection, with insects of the families Culicidae and the genus Culicoides. Seasonality was also observed, with the genus Culicoides having the largest number of individuals present during the rainy months. On the other hand, during the dry season *seca* an increase in Tabanidae larvae was observed in station A2, while the Empididae larvae decreased in the same location (Navas et al., 1995).

AQUATIC FAUNA

The different studies conducted reveal that the number of species of marine and freshwater fish is very close in Zone 5. Therefore, thirty-three (33) probable marine fish species and thirty-six (36) freshwater species were reported. This mixture of species could be an indication that the area closest to the brackish-water Miraflores Lake, acts as an estuary, allowing that marine species highly tolerable to climatic, physical and chemical changes to enter the Zone. According to studies, it is estimated that approximately eighty-two (82) invertebrates may be present. This Zone has a dominant presence of bivalve and gastropod mollusks, as well as an important presence of decapod crustaceans. The babillo and the jicoteca are the aquatic reptiles found in Zone 5. The presence of manatees in the Canal is corroborated in the zone between Paraiso and Pedro Miguel. The complete list of aquatic species collected from the revised studies is presented in Annex 3 – Aquatic Fauna Table 5-A8.

The results of the samplings of water bodies in the Area of Direct Impact (AID) by CEREB-UP (2005) are summarized in Tables 5-43 and 5-46. In general, creeks and streams present a higher diversity of fish and macroinvertebrates (crustaceans and mollusks) than the lagoons formed in the 1939 excavations.

Table 5-43

Richness of Taxa and Species of Fish and Macroinvertebrates Collected in the Water Bodies Sampled in the Area of Direct Impact (AID) in Zone 5, Excluding Miraflores Lake and the Canal

Water Body	Orders	Families	Species
North Lagoon	3	11	19
South Lagoon	6	11	19
Rivers and creeks	7	12	28

Source: URS basado en información de CEREB-UP (2005).

Table 5-44

Richness of Taxa and Species of Aquatic Fauna Verified in the Water Bodies Sampled in the Area of Direct Impact (AID) in Zone 5, Excluding Miraflores Lake and the Canal

CLASS	Orders	Families	Species
Fish	4	13	30
Crustaceans	1	6	12
Mollusks	2	2	2
Total	7	21	44

Source: URS Holdings, Inc. basado en información de CEREB-UP (2005).

The results obtained by CEREB-UP (2005) in North Lagoon can be compared with the results obtained in the study conducted by UNIPAN/ CCML-ACP (2004-2005) in the Miraflores Lagoon, which recorded 17 families, 30 genus, and 39 species in the lagoon. Of these, 54% (21) belong to the marine environment (peripherals) and 18 (46%) to freshwater environments (primary and secondary). CEREB-UP (2005) collected a total of four (4) orders, thirteen (13) families, twenty-four (24) genus, and thirty (30) fish species in Zone 5. Of these, eleven (11) species are characteristics of marine environments.

CEREB-UP recorded eight (8) marine species and eight (8) freshwater species North Lagoon (L-1), connected to Miraflores Lake; and identified twelve (12) species in South Lagoon (L-2), of which nine (9) are freshwater species and three (3) are marine species. In total, twenty-three (23) fish species, nine (9) marine and fourteen (14) freshwater, were documented in the two lagoons

formed by the 1939 excavations. It is worth noting that according to CEREB-UP, all marine species in the lagoons are classified as accidentals.

Four (4) orders, six (6) families, fourteen (14) genus, and seventeen (17) fish species were recorded in the creeks and rivers sampled by CEREB-UP; of these, fourteen (14) are freshwater and two (2) are marine species. The dominance of freshwater fish in the creeks and rivers sampled reveal a lesser influence of salt waters in these environments.

CEREB-UP (2005) did not record a single aquatic specie of special conservation interest in Zone 5.

5.5.3.6 Pacific Coast (Zone 6)

TERRESTRIAL FAUNA

The Pacific coast, identified as Zone 6 of the natural environment, covers the areas known as the Farfan River Swamp, Farfan Hill, the zone encompassed between the former Rodman Naval Station on the west side, and the industrial and residential areas of the Balboa twonsite, piers 17 and 18, the former Fort Amador, including the small mangrove areas to the south of the former Diablo townsite in the Post of Balboa, and the Velazques and Victoria dredged material disposal areas to the southeast of the Cocoli townsite. (Figure 5-7).

Zone 6 corresponds mostly to environments that have been historically highly altered by the development of the Canal Zone and the former United States military installations, including Howard Air Force Base, Rodman Naval Station, and the Rodman Ammunition Dump. In addition, it also includes the entrance to the 1939 excavations. The urban zones of Balboa, Corozal, Ancon, and Clayton are located east of the Canal.

The Farfan swamp area includes river mangrove communities and the wide grassland zones of the dredged disposal north of Farfan River which drains the Matutela River, east of the semideciduous forest of Farfan Hill, and the coastal mangroves south of Rodman Naval Base.

The main biodiversity study of Zone 6 was conducted by ANCON and TNC (1996a) in lands under the administration of the United States Department of Defense, during the U.S. Canal administration. This study considered the complex of installations and bases known as “HOROKO” west of the Canal as the best information available for Zone 6 of the specific study area (AEE).

The type of forest predominant in the area studied by ANCON-TNC within Zone 6 corresponds to a “mixed semideciduous seasonal forest,” and it is utilized as the representative forest; in any case, it is the type of forest presenting the highest diversity of fauna. In its important to note that in the Project’s area of direct impact (AID), the types of vegetation in addition to the one already mentioned are the mixed semideciduous seasonal forest, the mangrove forest, the shrubland, grassland and wetlands.

The type of vegetation with the highest diversity of vertebrate fauna is the mixed semideciduous seasonal forest, followed by the shrub (Table 5-45). The wetlands and the range are the habitat with the lesser diversity.

Table 5-45

Diversity of Species Recorded by Type of Vegetation in the HOROKO Complex

Types of Vegetation	Taxa						Total Fauna
	Mammals	Aves			Reptiles	Amphibians	
		Migratory	Resident	Totals			
Semideciduous Mixed Seasonal Forest	31	11	66	77	13	13	134
Mangrove	15	16	60	76	1	0	93
Shrubland	17	18	59	77	3	0	97
Grassland	3	11	43	54	3	2	62
Wetland	3	6	27	33	3	3	42

Source: ANCON – TNC, 1996a

The Arraijan entomofauna sampling station, A 1, utilized by Navas et al. (1995) is located within Zone 6 of this study, with the order Ephemeroptera being the most collected there. With regards to the seasonality observed, it was reported the the major seasonal fluctuations were observed in the collections of Ceratopogonidae and Culicidae, which were only observed during the rainy season.

AQUATIC FAUNA

The Pacific coast or Zona 6 has a predominance of marine fish, inasmuch as Panama Bay reflect the dynamics characteristic of the Ishmus southern coast. These coasts are highly productive due to the yearly upwelling phenomena and support one hundred and sixty-seven (167) reported marine species. The freshwater fish documented by the revised studies only reached three (3) species. The number of invertebrate species reported for the Zone totals two hundred and eighty-one (281), dominated mostly by bivalve mollusks. This is characteristic of the environmental conditions of the Zone, if we take into consideration the continental platform slope in Panama's Pacific, which presents the adequate conditions for the development of these organisms. There is a limited presence of coral reefs in Zone 6, concentrated around the islands of Taboga, Uraba and Taboguilla (Guzmán and Holst 1994 a, b). The corals in the Project's Pacific zone do not form any imporant reefs. The babillo has also been reported in Zone 6. The complete list of aquatic species documented by the revised studies are presented in Annex 3 – Aquatic Fauna Table 5-A9.

5.5.4 Indicator Species

5.5.4.1 Definition and Characteristics of the Indicator Species

Utilized for purposes of identifying the fauna that could be considered indicators of the quality of the existing ecosystems was Morrison et.al. (1998), which was cited in Chávez-León et al. (2005), Candanedo and Samudio (2005); Condit et al. (2001); Ibáñez et al. (2001); Soler (2002), Putz et al. (2000); Welsh and Ollivier (1998); Ruelas (1996); and Fenton et al. (1992). With regards to the aquatic fauna, FACINET/CCML-ACP 2004 y 2005 and URS Holdings, Inc.

(2004) were utilized. Within these approaches, populations of species and particular species that could act as indicators for the area of direct impact (AID) as well as for the Project's specific study area (AEE) and AEG, were proposed.

The Ramsar Convention Secretariat (2004) defines an indicator species as a species whose status provides information on the overall condition of an ecosystem and of other species in that ecosystem; they are usually taxa which are sensitive to the environmental conditions and which can, therefore, be used to assess environmental quality. They can also be invasive species or species tolerant of adverse conditions whose presence indicate a deterioration of the environment. Since it is very difficult to monitor and manage all aspects of the biodiversity that could be of interest—including species richness and composition, physical structure and processes—, it has been proposed to take a series of alternative steps and focus the attention on one or a few species; of these, the most used option has been that of indicator species (Simberloff, 1998). The so-called indicator species, biological indicators, bioindicators or ecological indicators constitute categories of species important to the management of natural resources, including endangered species, threatened species, with socioeconomic value, and those that are ecologically representative of specific environments, or of other species which may be associated to those environments (Morrison et al., 1998 cited in Chávez-León et al., 2005).

The use of bioindicators serve as a conservation tool that may be used to estimate environmental changes or changes in habitat quality. In this context, considered biological indicators are those organisms whose presence, absence, abundance or rarity could be used to gain better knowledge of the characteristics of the environment or ecosystem, or of some stage of the ecological succession process, or the effect of certain artificial influences or uses given to a natural area.

The species that can usually be used as indicators in a Project usually share some of the following characteristics: endemism, habitat specialization, rarity, sensitivity to habitat perturbations, limited distribution area, low reproductivity rate, or some type of specialization. The selection of one species or some species as indicators is a process that should be carried out under a careful study of the characteristics of the particular environment as well as of the species proposed for selection as an indicator species.

Furtive and ilegal hunting activities, which cause a decline in the number of fauna elements, be it for food, ornamental or commercial purposes, can also be cited as causing an adverse effect on the terrestrial fauna. Last but not least important, are the adverse effects on the terrestrial fauna of cattle raising and agricultural activities, which tend to slowly increase as human populations increase and inhabit the Canal region.

In the area of direct impact (AEA) of the Panama Canal Expansion Project – Third Set of Locks, a series of investigations on various fauna components that allow to determine some elements susceptible to be used as indicators of water quality and the status of aquatic and wet environments were carried out. This is the case of aquatic insects and amphibians (Candanedo and Samudio, 2005; Condit et al., 2001; Ibáñez et al., 2001).

Within the framework of approaches for indicator species, populations of species and particular species of terrestrial and aquatic animals that act or could act as indicators considering Project's Area of Direct Impact and well as the Specific Study, are proposed. These specific elements of the terrestrial and aquatic fauna could be used as indicators of: contamination, habitat destruction or modification or the possible effects of illegal hunting, according to their particular characteristics. For this purpose, information from scientific articles resulting from monitoring the Canal watershed (Ibáñez, 2002; Ibáñez et al., 2001; Condit et al., 2001); and the monitoring of indicators performed (Candanedo y Samudio, 2005), as well as other sources which cover these and other indicators applicable to the case of the Panama Canal Watershed (Chávez-León et al., 2005; Soler, 2002; Putz et al., 2000; Welsh y Ollivier, 1998; Ruelas, 1996; Fenton et al., 1992) was utilized.

5.5.4.2 Terrestrial Fauna

MAMMALS

Among the mammal, bats have been considered good indicators of the forest status because of their sensitivity to forest disturbances (Putz et al., 2000; Fenton et al., 1992), in particular substrate insectivorous bats (Fenton et al., 1992). Given to the fact that bats represent more than 50% of the mammal fauna and that, within this order, the insectivorous represent less than 20% of the existing species, reason why this group could be considered an indicator of the status of the forest within the Project's AEA.

Other mammals identified as indicator species are the otters; this is because these carnivorous mammals are organisms highly related with the aquatic environment. The effects caused by humans on these environments are severe for the otter population (Soler, 2002). Within the specific study area (AEE) the otters have been reported only within the mangrove forests in Zone 1. Also for the specific study area (AEE) medium to large caviomorph rodents such as paca and capybara and the ungulates such as deers and peccaries could also be used as indicators of hunting and deforestation effects, in addition to being related to the stability or decrease in the population of certain seed dispersor animals in the forest (Condit et al., 2001).

BIRDS

Most of the cracid bird species are found in the primary lowland forests, either wet or deciduous, in the cloudy mountain forest and gallery forest; except for the gray-headed chachalacas. These birds are very selective with regards to a particular habitat (Silva y Strahl, 1991). The populations of larger cracid birds such as the great curassow and the crested guan especially are susceptible to human perturbances (Silva y Strahl, 1991) and could be considered indicators. Taking into consideration that three (3) species of the Family Cracidae were reported in the specific study area (AEE), three (3) in the Atlantic and two (2) in the Pacific, these could also be used as indicators of the forest's health.

Birds of prey have also been cited as indicators since they are predator species highly susceptible to hábitat alterations caused by humans (Ruela, 1996). Because of the presence of birds of prey, it can be inferred that presence of other species used as prey is stable in this particular environment and that the food resources used by these preys are also available and in good condition.

REPTILES

Within the reptile group, the caiman or babilla (*Caiman crocodilus fuscus* Linnaeus, 1758), is recognized by its presence in the six (6) zones (from the Atlantic to the Pacific) of the Panama Canal. Different works show their large abundance and wide distribution in the Environmental Study Area (AEA) (ACP 2006i, CEREB 2005, URS Holding 2004, CEREB 2003, Ibáñez et al. 1995). In addition, the presence of crocodiles (*Crocodylus acutus*) has been recorded in zones 1, 2, 5, and 6. Their eating habits and great competitiveness, as regards to the capture of a large number of aquatic fauna organisms, place them at the top of the food chain, therefore, they become an important indicator specie as to the changes in the availability of minor vertebrates in the trophic chain of the aquatic ecosystems. In addition, the babillos and crocodiles are sensitive to ilegal hunting, which could develop if proper control measures are not established for the Project's area.

AMPHIBIANS

Amphibians are considered important indicators of the ecosystem's health because of their susceptibility to stressor such as environmental contaminants, introduction of exotic predators, infectious agents, parasites, and the effects of ultraviolet radiation (Welsh and Ollivier, 1998). Amphibians are also good indicators of aquatic or wet habitats; the number of amphibian species present in streams can be a good indicator of the ecosystem status, with easily recorded parameters (Ibáñez et al., 2002; Condit et al., 2001). The work method with amphibians to estimate the status of the wet environments (Ibáñez et al., 2001) has been validated in the field in the Panama canal lowland based on the number of amphibian species present; it presents a gradient that ranges from a good to poor status. In addition to have been used in different stages

of the Canal Watershed Monitoring Project, this method has been considered by other studies within this watershed, specifically in the region of Alto Chagres (Candanedo and Samudio, 2005). Therefore, if validated for the Project's area, this aspect could be reinforced as an important element to compare the conditions in different sectors within the General Study Area (AEG).

Table 5-46 summarizes the groups of terrestrial vertebrate fauna species used as indicators of the environmental status of the Project's area.

Table 5-46
Group of Species of Terrestrial Vertebrate Fauna Used as Indicators

CLASS	ORDER	GROUP	ZONES
Mammals	Chiroptera	Bats	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6
	Carnivora	Mustelidae	Zone 1, Zone 5, Zone 6
	Rodents	Caviomorphs	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6
	Ungulates	Deers, saínos	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6
Birds	Galliformes	Cracids	Zone 1, Zone 3
	Falconiformes	Birds of Prey	Zone 1, Zone 2, Zone 5
Amphibians	Anura	Frogs and Toads	Zone 1, Zone 3, Zone 4
Reptiles	Crocodylia	Babillo	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6
		Cocodrilo aguja	Zone 1, Zone 2, Zone 5, Zone 6
Zone 1: Atlantic Coast Zone 2: Gatun Locks		Zone 3: Gatun Lake Zone 4: Culebra Cut	Zone 5: Pacific Locks Zone 6: Pacific Coast

Source: URS Holdings, Inc.

5.5.4.3 Aquatic Fauna

It was decided to select as indicator species of the aquatic fauna those species revealed among its distinctive characteristics: wider range of distribution and/or greater abundance, throughout the entire Panama Canal or in specific zones of certain size, as well as their eating habits, level of tolerance to environmental changes, and /or development and importance within the trophic trama of the specific study area (AEE). Taking the aforesaid into account, the selected species included one (1) crustacean, two (2) molluks, four (4) fishes, and two (2) reptiles (Table 5-47).

Table 5-47
Aquatic Fauna Indicator Species

Family	Specie	Common Name	Tolerance Level	Zone
CRUSTACEANS				
Palaemonidae	<i>Macrobrachium amazonicum</i> (Rathbun, 1912)	River prawn	B	Zona e, Zone 3, Zone 4
MOLLUSKS				
Curbiculidae	<i>Corbicula fluminea</i> (Muller, 1774)	Freshwater claim	M	Zone 2, Zone 3, Zone 4, Zone 5
Thiaridae	<i>Melanooides tuberculata</i> (Muller, 1774)	Black snail	M	Zone 2, Zone 3, Zone 4, Zone 5
FISH				
Cichlidae	<i>Cihla monoculus</i> (Spix & Agassiz, 1831)	Peacock bass	M	Zone 2, Zone 3, Zone 4, Zone 5
Characidae	<i>Astyanax ruberrimus</i> (Eigenmann, 1907)	Sardine	M	Zone 2, Zone 3, Zone 4, Zone 5
Megalopidae	<i>Megalops atlanticus</i> (Valenciennes, 1841)	Tarpon	A	Zone 1, Zone 2, Zone 3, Zone 4, Zone 5, Zone 6
Poeciliidae	<i>Gambusia nicaraguensis</i> (Günther, 1866)	Mosquitofish	B	Zone 2, Zone 3, Zone 4,
Tolerance Level: A- High M- Medium B- Low				
ZONE 1: Atlantic Coast		ZONE 3: Gatun Lake	ZONE 5: Pacific Locks	
ZONE 2: Gatun Locks		ZONE 4: Culebra Cut	ZONE 6: Pacific Coast	

Sources: Fundación Universidad de Panamá (FUDEP) based on ACP (2006), PB Consult (2006), Averza Colamarco (2005), CEREB (2005), FACINET/CCML-ACP 2004 and 2005, URS Holdings, Inc. (2004), CEREB (2003), , Gutiérrez et al. (1995), Ibáñez et al. (1995), Zaret & Paine (1973).

Among the group of crustaceans, the *Macrobrachium amazonicum* (Rathbun, 1912), known as river prawn, was selected among all other existing species of crustacean for its extraordinary abundance in zones (Zone 2 through Zone 4) where they are found, exclusively freshwater (CEREB 2005, FACINET/CCML-ACP. 2004 and 2005 , URS Holdings, Inc. 2004). This makes it extremely important to the development of the food chain sequenciation; in addition, their bentonic habits and the fact that they are linked to vegetation, constitute an excellent indicator of environmental changes .

The freshwater clam, *Curbicula fluminea* (Muller, 1774), is the most abundant fresh water mollusk and the one with the widest distribution (CEREB 2005, FACINET/CCML-ACP 2004 and 2005, URS Holdings, Inc. 2004, CEREB 2003), within the locks zone (Zone 2 through Zone 5). As a benthic organism (bottom dweller) and filtrator, it has the characteristic of concentrating, any type of foreign component, found in the water column; this makes it an excellent organism to be considered an indicator species. The black snail, *Melanoides tuberculata* (Muller, 1774), although of lesser size, is a highly abundant and amply distributed organism (Zone 2 through Zone 5); and by being associated with a variety of environments (aquatic plants, islands, rocky bottoms, submerged woods, etc.), its presence is highly important as an indicator species (CEREB 2005, FACINET/CCML-ACP 2004 y 2005, URS Holdings, Inc. 2004, CEREB 2003).

The fish group presents species such as the *Cichla monoculus* (Spix & Agassiz, 1831), which is a carnivorous cichlids introduced into the Panama Canal system in 1967 (Zaret & Paine 1973, González 1995), shows a wide distribution in the Panama Canal freshwaters, from Zone 2 through Zone 5 (CEREB 2005, FACINET/CCML-ACP. 2004 and 2005, URS Holdings, Inc. 2004, CEREB 2003, Gutiérrez et al. 1995). It is known that under certain adverse circumstances, this species is prone to die in large numbers, and this makes it a species of diagnostic importance within the freshwater environment. Its population is under pressure as a result of artisanal and sport fishing (fishermen's cooperative and national and international fishing tournaments); however, its biological characteristics allow them to remain in its environment, unless such environment is modified. The *Astyanax ruberrimus* (Eigenmann, 1907), known as the Panama sardine, is considered a highly important indicator species since it is a widely distributed species found only in the freshwaters of the Canal (Zone 2 through Zone 5) (CEREB 2005, FACINET/CCML-ACP. 2004 y 2005, , URS Holdings, Inc. 2004, CEREB 2003, Gutiérrez et al. 1995), is food for many carnivorous species and is highly susceptible to changes in its environment.

As regards to the tarpon, *Megalops atlanticus* (Valenciennes, 1841), its characteristics, which include breathing atmospheric air in anoxic waters, feeding from a wide spectrum of organisms

through their life cycle, its permanent presence within the Panama Canal system, and its strength, made him a greatly important indicator species.

The most abundant fish as regards to number of individuals present in Canal freshwaters belongs to the Family Poeciliidae, the mosquitofish or *Gambusia nicaraguensis* (Günther, 1866) (CEREB 2005, FACINET/CCML-ACP. 2004 and 2005 , URS Holdings, Inc. 2004, CEREB 2003, Gutiérrez et al. 1995); thus, it is a species of high ecological importance for the specific study area (AEE) and a great indicator of adverse environmental changes. Because of these characteristics, and for being one of the predominant freshwater species, it was included among the indicator species.

5.5.5 Threatened, Vulnerable, Endemic or Endangered Species

5.5.5.1 Definitions and Lists Consulted

Of the species inhabiting the specific study area of the Panama Canal Expansion Project – Third Set of Locks, several are in different stages of vulnerability or in danger of becoming extinct. There is a myriad of reasons associated to this situation: current direct exploitation, isolated populations due to other uses given to the land or geographically restricted in its natural distribution, decrease of available habitat, and influence of other development activities being carried out in the region (ANCON, 1995), in addition, the introduction of species which compete with the native species for the existing resources (González, 2000), among other reasons.

The sources of information reviewed to analyze the threatened status, endemism or danger of the wildlife species recorded for the specific study area (AEE) include regional and national lists on endangered species, threatened species, or species affected by international trade (UICN, 2006; Samudio et al., 2002; UICN-ORMA, 1999; RENARE, 1980) as well as documents particular to the general study area which cover the record, distribution and relative abundance of the species inhabiting the region (CEREB-UP, 2005; FACINET/CCML-ACP, 2004 and 2005; The Louis Berger Group, Inc., 2004 a, 2004 b, 2004 c, 2004 d; URS Holdings, Inc., 2004b; ACP – UP, 2003; Samudio, 2002; Ibáñez et al., 2001; ANCON-TNC, 1996 a, b; ANCON 1995).

The national and international lists consulted to determine the status of threatened or endangered species are the following:

- Resolution 002-80 of the Ministry of Livestock and Agriculture Development (National Bureau of Renewable Natural Resources -RENARE)
- 2006 IUCN Red List of Threatened Species (UICN, 2006)
- Appendixes I and II. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2007).

5.5.4.2 Endemic Species

The endemic species of Panama's vertebrate fauna expected and verified for the specific study area (AEE) are grouped in three (3) mammals, one (1) bird, two (2) reptiles, and one (1) amphibian:

- Panamanian spiny pocket mouse (*Liomys adpersus*)
- Darien harvest mouse (*Reinthrodontomys dariensis*)
- Rothschild's porcupine or arboreal porcupine (*Coendou rothschildi*)
- Yellow-green Tyrannulet (*Phylloscartes flavovirens*)
- Polychrotidae lizard (*Anolis lionotus*)
- Snail sucker snake or Culebra caracolera (*Dipsas nicholsi*)
- Sapo limoso (*Atelopus limosus*).

Of these seven species, only the arboreal porcupine was observed in the area of direct impact (AID) by CEREB-UP (2005). The arboreal porcupines are found throughout most of the country, except for the Central Range and the Western Atlantic Coast (Samudio, 2002).

The *Liomys adpersus* or Panamanian spiny pocket mouse is found on the Pacific side of the watershed of the Isthmus, including the Azuero peninsula and the eastern region up to Bayano Lake (Samudio, 2002). It is important to clarify that although the presence of the arboreal porcupine has been reported throughout most of the country, it has not found in the western

Atlantic coast nor in the Central Range (Samudio, 2002). The Panamanian spiny pocket mouse has been classified as a near threatened species (NT) by the UICN.

The Darien harvest mouse, *Reinthonomys dariensis*, inhabits the Azuero peninsula, the Cana watershed, the Eastern region of the Panamanian isthmus, and Alto Darien, up to 900 msnm (Samudio, 2002). This species has not been included in the conservation categories in the national or international conservation lists.

The yellow-green tyrannulet is a bird which inhabits eastern Panama from Gatun Lake to almost the the border with Colombia, especially in the Pacifici and occupies a range of approximately 17,000 km² (BirdLife International, 2004).

The Polychrotidae lizard is common in the the Atlantic side of the watershed and the shores of creeks and has been found by Gatun Lake (Campbell, 1973). Very few specimens of the snail sucker snake are known, and these have been collected in the Specific Study Area (AEE) of Zone 4 near the Summit in the Alhajuella forests, and area formerly known as Madden (Myers et al., 2007). The sapo limoso is a species yet not very well known found in the high zone of the Chagres watershed (Ibáñez et al., 1995) and is categorized as an endangered species (EN) by UICN. Although its presence in the altered habitats in the Area of Direct Impact (AID) is very unlikely, its potential presence in lower zones of the Chagres River inside the Area of Specific Study (AEE) has not been ruled out.

5.5.4.3 Threatened or Endangered Fauna

The information sources reviewed to analyze the status of threatened endemismo or endangered of the wild life recorded for the AEA include regional and national lists on endangered, threatened and species affected by international trade: UICN (2004); Samudio et al. (2002); UICN-ORMA (1999); y RENARE (1980); as well as documents particular to the general study area which cover the record, distributuion, and relative abundance of the species occupying the region: CEREB-UP (2005); FACINET/CCML-ACP (2005); The Louis Berger Group, Inc., (2004 a, 2004 b, 2004 c, 2004 d); FACINET-CCML-ACP (2004); URS Holdings, Inc. (2004b);

ACP – UP (2003); Samudio (2002); Ibáñez et al. (2001); ANCON-TNC (1996 a, b); and ANCON (1995). The studies reviewed suggest the presence of a diversity of faune species included in the RENARE Resolución 002-80, the IUCN Red List, and CITES Appendixes. Table 5-46 summarizes the species potentially present in the Project's Specific Study Area (AEE) and/or the Area of Direct Impact (AID).

Table 5-48
Species in the National and International Lists of Threatened Species with Potential Presence in the Specific Study Area (AEE) and Area of Direct Impact (AID)

Scientific Name	Common Name	Endemic	ANAM	IUCN	CITES	Zones					
						Z1	Z2	Z3	Z4	Z5	Z6
Mammals											
<i>Caluromys derbianus</i>	Woolly opossum			VU				X	X	X	
<i>Chironectes minimus</i>	Water opossum			NT							
<i>Trichechus manatus</i>	Manatee		X	VU	I			X	X	X	
<i>Dasybus novemcinctus</i>	Armadillo		X			X	X	X	X	X	X
<i>Cabassous centralis</i>	Naked-tailed armadillo		X								
<i>Bradypus variegatus</i>	Three-toed sloth				II	X	X				
<i>Cyclopes didactylus</i>	Silky anteater		X			X					
<i>Tamandua mexicana</i>	Anteater		X			X	X	X	X	X	X
<i>Saguinus geoffroyi</i>	Titi marmoset				I	X	X	X	X	X	X
<i>Cebus capucinus</i>	White-headed Capuchin		X		II		X				
<i>Alouatta palliata</i>	Howler monkey		X		I	X	X		X	X	
<i>Ateles geoffroyi</i>	Spider monkey		X		II			X			
<i>Aotus lemurinus</i>	Owl monkey or night monkey		X		II	X	X	X	X	X	X
<i>Liomys adspersus</i>	Panamanian spiny pocket mouse	X		NT							X
<i>Reithrodontomys dariensis</i>	Darien harvest mouse	X									
<i>Coendou rothschildi</i>	Rothschild's porcupine or arboreal porcupine	X				X	X	X	X	X	
<i>Hydrochoerus isthmius</i>	Panama Capybara		X				X	X	X	X	X
<i>Dasyprocta punctata</i>	Central American agoutis		X			X	X	X	X	X	X
<i>Cuniculus paca</i>	Agouti paca		X			X	X	X	X	X	
<i>Diphylla ecaudata</i>	Hairy-legged vampire bat			NT							
<i>Panthera onca</i>	Jaguar		X					X			
<i>Leopardus pardalis</i>	Ocelot		X		I	X		X	X	X	
<i>Leopardus wiedii</i>	Margay or tree ocelot		X		I			X			
<i>Puma concolor</i>	Cougar or mountain lion		X					X			
<i>Puma yagouaroundi</i>	Jaguarundi		X		I	X		X	X	X	X

Scientific Name	Common Name	Endemic	ANAM	IUCN	CITES	Zones					
						Z1	Z2	Z3	Z4	Z5	Z6
<i>Urocyon cinereoargenteus</i>	Gray fox		X								
<i>Lontra longicaudis</i>	Neotropical river otter		X		I	X	X	X	X	X	X
<i>Bassaricyon gabbii</i>	Olingo			NT							
<i>Nasua narica</i>	Coati or coatimundi		X			X	X	X	X	X	
<i>Procyon cancrivorus</i>	Crab-eating raccoon		X				X			X	
<i>Procyon lotor</i>	Raccoon		X			X	X	X	X	X	X
<i>Tapirus bairdii</i>	Tapir		X	VU	I			X			
<i>Pecari tajacu</i>	Peccary		X		II	X		X			X
<i>Mazama americana</i>	Red brocket deer		X			X		X		X	
<i>Odocoileus virginianus</i>	White-tailed deer		X			X		X	X	X	X
Birds											
<i>Tinamus major</i>	Great tinamou		X			X					
<i>Crypturellus soui</i>	Little tinamou		X			X		X	X	X	X
<i>Dendrocygna autumnalis</i>	Black-bellied whistling duck		X							X	X
<i>Cairina moschata</i>	Muscovy duck		X					X			
<i>Anas clypeata</i>	Northern shoveler		X								
<i>Anas acuta</i>	Northern pintail		X								
<i>Aythya affinis</i>	Lesser scaup		X								
<i>Oxyura dominica</i>	Masked duck		X								
<i>Pandion haliaetus</i>	Osprey				II	X	X	X	X	X	X
<i>Leptodon cayanensis</i>	Gray-headed kite				II						
<i>Chondrohierax uncinatus</i>	Hook-billed kite				II	X					
<i>Elanoides forficatus</i>	Swallow-tailed kite				II						
<i>Gampsonyx swainsonii</i>	Pearl kite				II						
<i>Elanus leucurus</i>	White-tailed kite				II					X	X
<i>Rostrhamus sociabilis</i>	Snail kite				II						
<i>Harpagus bidentatus</i>	Double-toothed kite				II	X			X		X
<i>Ictinia mississippiensis</i>	Mississippi kite				II						
<i>Ictinia plumbea</i>	Plumbeous kite				II						
<i>Accipiter superciliosus</i>	Tiny sparrowhawk				II						
<i>Accipiter bicolor</i>	Bicoloured hawk				II						
<i>Geranospiza caerulescens</i>	Crane hawk				II						
<i>Leucopternis plumbea</i>	Plumbeous hawk			NT	II	X					
<i>Leucopternis semiplumbea</i>	Semiplumbeous hawk				II	X					
<i>Leucopternis albicollis</i>	White hawk				II						
<i>Buteogallus anthracinus</i>	Common black-hawk				II	X				X	
<i>Buteogallus urubitinga</i>	Great black-hawk				II					X	

Scientific Name	Common Name	Endemic	ANAM	IUCN	CITES	Zones					
						Z1	Z2	Z3	Z4	Z5	Z6
<i>Buteogallus meridionalis</i>	Savanna hawk				II						
<i>Asturina nitida</i>	Gray hawk				II					X	
<i>Buteo magnirostris</i>	Roadside hawk				II						
<i>Buteo platypterus</i>	Broad-winged hawk				II	X			X	X	
<i>Buteo brachyurus</i>	Short-tailed hawk				II						
<i>Buteo swainsoni</i>	Swainson's hawk				II						
<i>Buteo albonotatus</i>	Zone-tailed hawk				II						
<i>Buteo jamaicensis</i>	Red-tailed hawk				II						
<i>Spizastur melanoleucus</i>	Black-and-white hawk-eagle				II						
<i>Spizaetus tyrannus</i>	Black hawk-eagle				II		X				
<i>Spizaetus ornatus</i>	Ornate hawk-eagle				II						
<i>Polyborus plancus</i>	Crested caracara				II						X
<i>Milvago chimachima</i>	Yellow-headed caracara				II						
<i>Herpetotheres cachinnans</i>	Laughing falcon				II		X			X	
<i>Micrastur ruficollis</i>	Barred forest-falcon				II						
<i>Micrastur mirandollei</i>	Slaty-backed forest-falcon				II						
<i>Micrastur semitorquatus</i>	Collared forest-falcon				II	X					X
<i>Falco sparverius</i>	American kestrel				II					X	
<i>Falco columbarius</i>	Merlin				II						
<i>Falco rufigularis</i>	Bat falcon				II					X	
<i>Falco peregrinus</i>	Peregrine falcon		X		I						
<i>Crax rubra</i>	Great curassow		X	NT							
<i>Penelope purpurascens</i>	Crested guan		X			X				X	
<i>Ortalis cinereiceps</i>	Gray-headed chachalaca		X			X		X	X	X	X
<i>Odontophorus gujanensis</i>	Marbled wood-quail		X								
<i>Tryngites subruficollis</i>	Buff-breasted sandpiper			NT							
<i>Columba cayennensis</i>	Pale-vented pigeon		X			X	X	X	X	X	X
<i>Columba speciosa</i>	Scaled pigeon		X			X			X	X	
<i>Columba nigrirostris</i>	Short-billed pigeon		X			X					X
<i>Geotrygon violacea</i>	Violaceous quail-dove		X								
<i>Aratinga pertinax</i>	Brown-throated parakeet				II						
<i>Brotogeris jugularis</i>	Orange-chinned parakeet				II	X	X	X	X	X	X
<i>Pionopsitta haematotis</i>	Brown-hooded parrot				II						
<i>Pionus menstruus</i>	Blue-headed parrot				II	X		X	X	X	X
<i>Amazona autumnalis</i>	Red-lored Amazon				II	X	X	X	X	X	X
<i>Amazona ochrocephala</i>	Yellow-crowned Amazon		X		I					X	
<i>Amazona farinosa</i>	Mealy Amazon				II						
<i>Tyto alba</i>	Common barn owl				II						

Scientific Name	Common Name	Endemic	ANAM	IUCN	CITES	Zones					
						Z1	Z2	Z3	Z4	Z5	Z6
<i>Otus guatemalae</i>	Vermiculated screech-owl				II						
<i>Otus choliba</i>	Tropical screech-owl				II						
<i>Lophostrix cristata</i>	Crested owl				II						
<i>Pulsatrix perspicillata</i>	Spectacled owl				II						
<i>Glaucidium minutissimum</i>	Least pygmy owl				II						
<i>Ciccaba virgata</i>	Mottled owl				II						
<i>Ciccaba nigrolineata</i>	Black-and-white owl				II						
<i>Asio clamator</i>	Striped owl				II						
<i>Glaucis aenea</i>	Bronzy hermit				II						
<i>Glaucis hirsuta</i>	Rufous-breasted hermit or hairy hermit				II	X		X	X	X	X
<i>Threnetes ruckeri</i>	Band-tailed barbthroat				II				X	X	X
<i>Phaethornis superciliosus</i>	Long-tailed hermit				II	X	X	X	X	X	X
<i>Phaethornis anthophilus</i>	Pale-bellied hermit				II						
<i>Phaethornis longuemareus</i>	Little hermit				II	X	X	X	X	X	X
<i>Phaeochroa cuvierii</i>	Scaly-breasted hummingbird				II						
<i>Florisuga mellivora</i>	White-necked jacobin				II	X	X	X	X	X	X
<i>Anthracothorax nigricollis</i>	Black-throated mango				II		X				X
<i>Lophornis delattrei</i>	Rufous-crested coquette				II						
<i>Chlorostilbon assimilis</i>	Garden emerald				II	X		X	X	X	X
<i>Thalurania colombica</i>	Violet-crowned woodnymph				II						
<i>Damophila julie</i>	Violet-bellied hummingbird				II	X	X	X	X	X	X
<i>Lepidopygia coeruleogularis</i>	Sapphire-throated hummingbird				II	X		X	X	X	X
<i>Hylochlaris eliciae</i>	Sapphire-throated hummingbird				II						
<i>Amazilia amabilis</i>	Blue-chested hummingbird				II	X					X
<i>Amazilia edward</i>	Snowy-bellied hummingbird				II			X	X	X	X
<i>Amazilia tzacatl</i>	Rufous-tailed hummingbird				II	X	X	X	X	X	X
<i>Chalybura buffonii</i>	White-vented plumeleteer				II				X	X	X
<i>Chalybura urochrysis</i>	Red-footed plumeleteer				II	X					
<i>Heliophryx barroti</i>	Purple-crowned fairy				II		X				
<i>Heliomaster logirostris</i>	Long-billed star-throat				II						
<i>Ramphastos sulfuratus</i>	Keel-billed toucan				II	X	X	X	X	X	X

Scientific Name	Common Name	Endemic	ANAM	IUCN	CITES	Zones					
						Z1	Z2	Z3	Z4	Z5	Z6
<i>Phylloscartes flavovirens</i>	Yellow-green tyrannulet	X									
<i>Dendroica cerulea</i>	Cerulean warbler			VU							
<i>Vermivora chrysoptera</i>	Golden-winged warbler			NT							
Reptiles											
<i>Caiman crocodilus fuscus</i>	Babillo or bown caiman		X		II	X	X	X	X	X	X
<i>Crocodylus acutus</i>	American crocodile		X	VU	I	X	X			X	X
<i>Rhinoclemmys annulata</i>	Brown land turtle or borwn wood turtle			NT						X	
<i>Trachemys scripta</i>	Slider			NT		X	X	X	X	X	X
<i>Boa constrictor</i>	Boa constrictor		X		II	X	X	X	X	X	X
<i>Corallus anulatus</i>	Annulated tree boa				II						
<i>Dipas nicholsi</i>	Culebra caracolera								X		
<i>Iguana iguana</i>	Green iguana		X		II	X	X	X	X	X	X
<i>Anolis lionotus</i>	Tropical Anolis lizard	X						X			
Amphibians											
<i>Atelopus limosus</i>	Sapo limoso	X		EN				?			
<i>Lithobates warszewitschii</i>	Warszewitsch's frog			NT		X	X	X			
<i>Dendrobates auratus</i>	Green poison dart frog				II	X	X	X	X	X	X
<i>Phyllobates lugubris</i>	Lovely poison-dart frog				II			X			
<i>Ranitomeya fulgurita</i>	True dart frog				II						

Source: CEREB-UP (2005) modificado por URS Holdings, Inc.

5.6 Fragile Ecosystems and Representativity of Ecosystems

The determination of fragile ecosystems was made base don the susceptibility of these ecosystems to the introduction of external factors. Their representativity is based on the fact that the characteristics typical of the ecosystem are the best to represent a specific environment within one region.

As source of reference for this subject, the following studies were consulted: ANCON (1995); ANCON – TNC (1996 a, b); Condit et al. (2001); ACP, (2006,i); CEREB-UP (2003); González A, Alvarado-Durfee G and Díaz C. (1974); ICA.EsIA Creation of the Punta Pacífica Islands

(1999); M&N-LBG (2002-2004); Moffat & Nichol/Golder Ass. (2005); e IDB. Panama City and Bay Sanitation Project (2006).

5.6.1 Fragile Ecosystems

A fragile ecosystem is that in which the environments are highly susceptible to the extinction of its natural populations, or that its diversity or stability conditions decrease or disappear dangerously by the introduction of foreign factor or exogens. Taking this definition into consideration as well as the ecosystems described in previous sections for the area of direct impact and the specific study area, there are fragile or environmentally sensitive ecosystems to be considered in this study.

The two ends of the region under study (Zones 1 Atlantic Coast and Zone 6 Pacific Coast) encompasses coastal and marine environments which include mangrove forests relatively fragile or susceptible to affectations. The northern end of the specific study area (AEE) or Zone 1 also includes an area of coral reefs (ANAM, 2000a) considered to be the most diverse reef in the Pacific (Guzmán y Holst 1994 a, b); these environments are susceptible to deterioration by a series of changes in the aquatic conditions. There is a limited presence of coral reefs in Zone 6, concentrated around the islands of Taboga, Uraba and Taboguilla (Guzmán and Holst 1994 a, b). The Panama vegetation map which introduces the categories used by UNESCO (United Nations Educational, Scientific and Cultural Organization) shows the location of the reefs in both coastal sectors (ANAM, 2000a).

With regards to forests, it is indicated that Zone 1 in the specific study area (AEE) includes native forests in good conservation status; this species, *Prioria copaifera*, is under threat in other parts of the Country from commercial exploitation by the plywood and wood industry (ANCON-TNC, 1996b). It is worth mentioning that this species is not very well represented in the Country's protected protegidas, and is used profitably in Darien where it is found in abundance (ANCON-TNC, 1996b).

In addition, there is a North to South vegetation corridor which changes from a more uniform coverage and from the category of a tropical ombrophile evergreen lowland latifoliated forest on the Atlantic side of the watershed, to a less uniform forest of the semideciduous tropical lowland category on the Pacific side of the watershed. This corridor encompasses the the Pacific Coast zone (zone 6) with semideciduous tropical lowland forests – highly intervened and, although altered, require attention because of they are scarce not only in Panama but in the rest of the Central American Isthmus (Condit et al., 2001).

As stated in the section covering the flora, the vegetation of the area of direct impact is mostly a vegetation of the secondary forest type, shrub and grassland. This is the case primarily in Zones 4, 5 and 6 which present more altered vegetation than in the Atlantic slope. In this sense, the environments to be affected, because of their condition, are not very important or representative. However, it is important to note the connectivity function that the patches of secondary forest may be exerting on neighboring sectors.

The environments around the Canal infrastructure in the Project's area of direct impact (AID), where the Canal expansion work will be carried out, have been constantly intervened over the past one hundred years. This is reflected on the slopes with soil retention Works among other aspects; therefore, these environments are hardly representative.

The coral, mangrove, cativo and semideciduous lowland forest environments indicated here require special attention and conservation programs.

5.6.2 Ecosystem Representativity

A representative ecosystem is an ecosystem showing optimum conditions to characterize this environment within a specific region. At first sight the ecosystem of the Canal watershed or of the General Study Area (AEG) have been altered, are not exclusive to this region, have been recorded in other sectors of the Country, and are even conserved and protected in other parts of Panama and the central American region. However, the General Study Area (AEG) stands out by maintaining a relative integrity in its ecosystems, and it is a challenge to conserve these

environments in the XXI Century with all the developments expected in this region (Condit et al., 2001). In addition, aside from the reasons linked to the conservation of forests for the production of water in sufficient quantities and quality for domestic and industrial use, the General Study Area (AEG) is an important link for the conservation of the environments where many species of fauna may continue to exist and move to insure their long-term genetic viability.

The Specific Study Area (AEE) as well as the General Study Area (AEG) do not have ecosystems in pristine conditions; there are environments similar to those in other regions of the Country, which have been protected in other parts Panama where they are more representative. In addition, within the Specific Study Area (AEE), these environments have been subject to alterations at different times. However, to insure the production of water in sufficient quantities and quality for the different uses required by the ACP and the metropolitan region, it is important to at least maintain a healthy vegetation within this Zone. Various sectors of the Specific Study Area have been protected taking into account these considerations.

5.6.2.1 Atlantic Coast (Zone 1)

A series of particular elements are present in this Zone within its Specific Study Area (AEE). The coral reef, mangroves, small bays and cliffs, the sublittoral and littoral zones, seagrass bed and estuaries in Zone 1, although of a biodiversity reduced by human impacts associated with the region's development (ACP, 2006i; Guzmán y Holst, 1994 a, b), are the survivors of the intensive utilization of this sector.

Limón Bay (~75 km²) is protected from wave action by a breakwater, which practically closes the connectivity to the ocean except for the entrance to the Canal, and a channel to the east which connects the ports of Manzanillo and Evergreen. There are some areas in this Bay, mostly towards the west, which are remains of the previous environment, and where coral, seagrass beds and other benthic fauna and flora are found, although not in good condition (ACP, 2006i).

This Bay is mainly used for Canal purposes, where its maintenance and operation have historically and presently been associated with the disposal of dredged material. However, the

quality of the water is acceptable and the concentration of heavy metals in the sediments is within the normal range for these coastal areas (PB Consult, 2006). The Chagress River bed underneath Gatún Damm, in the Specific Study Area (AEE), has a water flow regulated by the Canal operation. It is important to note that there are also a few tributary rivers that empty their waters in this stretch. During most of the rainy season there is a constant flow of water underneath the damm due to the passage of those waters used by the ACP enery generation plant in their Gatun installations. Towards the end of the rainy season, the lower part of the Chagres River also receives high flows of water due to excess water in the Lake, with great volumes of water being spilled gradually by the Gatun Lake Spillway.

The portion joining the opening of the breakwater with the point where the Canal infrastructure being within Limon Bay is part of the area of direct impact (AID) (see detail in Figure 5-1); this includes a site for disposal of dredged materials. The lowlands, swamps, and mangroves of the southern border of Limon Bay, plus a border area in to the southeast with wild sugarcane has always been used for the disposal of dredged material. This use implies relative changes in the landscape which will continue in the area of direct impact.

It is worth mentioning that there are corals as well as mangrove and other environments relative to the coastal section, which are in a better status of conservation in two protected territories at the eastern and western ends of the marine coast of Zone I; this within the specific study area (AEE).

5.6.2.2 Gatun Locks (Zone 2)

The Gatun Locks zone, or Zone 2 in this study, is mostly comprised of sectors which orrespond to the area of direct impact (AID). This covers the land occupied by the Canal, the existing locks system, and the area of the 1939 excavations (abandoned in 1942 and presently covered by lagoons and different vegetation covers (secondary forests, shrubs, and grasslands, which coincide with the alignment of the proposed third set of locks. The Canal's aquatic environment is dominated by the locks operations and the transit of vessels.

The sectors corresponding to the specific study area (AEE) include a part of the José Dominador

Bazán residential area (former Fort Davis) and buildings belonging to the ACP and the former Gatun townsite. There are, in addition, areas covered by secondary forests, as well as areas kept free of vegetation due to the operations of the Canal, highly intervened secondary forest, and aquatic areas. There are no fragile or representative ecosystems in this Sector.

5.5.2.3 Gatun Lake (Zone 3)

The shores of the Lake are within this study's specific study area (AEE). They include forests in several stages of maturity as well as shrubs, grassland, and farming areas mostly located towards the southwest of the Lake, due to the establishment of agricultural and cattle farming. Gatun Lake was formed almost a century ago; the operating level of the Lake is controlled by a hydraulic spillway located on the western side of Gatun Lock; water overflows over this spillway towards the lower Chagres riverbed; this stretch is connected to the Atlantic Ocean. Because of the shape of the flooded valleys, the Lake is deeper on the northwestern side, reaching 25m in depth near the Gatun Locks.

The eastern half of Gatun Lake in the area of direct impact (AID) presents an aquatic sector with dredged regularly zones; in addition, there are three zones for the disposal of dredged material, which are filled below the water level to prevent the growth of hydrilla-type plants.

Gatun Lake, an artificial lake built a century ago, has developed its own ecology and aquatic biodiversity comparable to those of natural lakes. This lake provides the proper habitat to many species of Panamanian fauna (see the section on fauna in this chapter). Four conservation areas of natural, historic, and cultural resources have been established within this Zone: the Barro Colorado Island Natural Monument, the Gatun Lake recreational area, and the Soberania and Las Cruces Trail National Parks on the eastern margin. Among these conservation areas, Barro Colorado stands out for its seniority as a protected site for scientific studies, from the valley-filling to form the lake and for the numerous publications which have significantly broadened the

knowledge regarding tropical jungles of the new world (see the section on Protected Birds and Connectivity in this study).

5.5.2.4 Culebra Cut (Zone 4)

Culebra Cut, or Zone 4, covers from south to north, from the Pedro Miguel Locks to the Chagres River confluencia at Gamboa. Due to the excavations across the range diving the Isthmus and the complex geology of the Culebra and Cucaracha formations, this section of the Canal has always been an area subject to slides due to soil instability. Since 1970, the ACP has maintained a soil control program, which has included works to stabilize the slopes on both sides of the Canal. In addition, from the 1950's to the present, it has undergone several deepening cycles (presently ~14 m), widening (present minimum 190 m), and curve straightening. Due to these extensive works, the vegetation in this section of the Canal is limited to a dominant wild sugarcane and some areas of highly intervened secondary forest.

Along the cut are several land sites designated as sites for the disposal of dredged material extracted from the excavations from the lateral slope of the Canal; other areas within the lake receive wet material from dredging operations. The vegetation cover in this areas is comprised mostly of wild sugarcane and grasslands, followed by stubbles and remaining areas of altered secondary forest. The central sector in this Zone 4 corresponds to this study's area of direct impact (AID) where the existing disposal sites are located. There are no fragile or representative ecosystems in this Zone.

5.6.2.5 Pacific Locks (Zone 5)

The zone comprised by the Miraflores and Pedro Miguel Locks, separated by Miraflores Lake, include in the Canal's borders infrastructure and sectors of wild sugarcane plus secondary forests in different levels of intervention towards the south, as well as lagoons and secondary forest in sectors excavated between 1939 and 1942 towards the southwest. In addition, there are several land disposal historically and currently used for the disposal of dredged material (wet) or excavations (dry). This Zone includes, west of the Canal, part of the former Empire Firing

Range, which contains non-detonated explosive material. Waters present a level of mid-contamination caused by the sewage from populated areas in this Sector (ACP,2006i; The Louis Berger Group, Inc 2004). The flora and fauna pertaining to this Zone is predominantly aquatic (see the sections on fauna and vegetation in this chapter). This Sector's area of direct impact (AID) corresponds to the Zone's central region. There are no fragile or representative ecosystems within this section of the Project.

5.6.2.6 Pacific Coast (Zone 6)

This environment is dominated by the transit of vessels through the Canal and the port operations in the Balboa area. The coastal zone is mostly comprised by port, industrial or urban areas. Only in the southwestern corner are there some vegetation areas; an extensive swamp with a strip of mangrove, and small areas of secondary forest and wild sugarcane. Remnants of secondary forests of the semideciduous tropical lowland type – fairly intervened that, because of their scarcity, should be protected (Condit et al., 2001) stand out in the western sector.

In the study zone closest to the ocean and in shallow waters on the sides of the Canal, the combined action of waves and currents causes erosion and sediment circulation (ACP, 2006i). This zone of the Canal is identified as having a high level of sedimentation (ACP, 2006i). The estuary receives all the untreated sewage from Balboa, Ancon, and other urban areas of Panama City, through either river, channel, and pipe systems. The level of organic contamination is very high (organic solid waste, bacterias, pathogens, etc.); the origen of this contamination is the sewage system of Panama City with its fluids containing high concentrations of fecal coliforms. There are no good estimates of the residence time of the contaminated material in this Zone, or of its last destiny, but it is true that the dispersion vector is highly linked to the circulation of fine sediment and the dredging periods.

During the dry season, stronger north winds drives marine surface waters to the southwest, causing “outcropping” of cold waters from the ocean depths. In general, the stronger flows in Panama Bay are aligned from north to south, controlled by the effects of the tides, and the effect of the oceaninc current provides a component towards the west. The maximum speed of the

currents do not exceed ~0.3 m/s. The residual flow is directed towards the west or southwest (ACP, 2006i).

The waves (Moffatt & Nichol/Golder Ass. 2005) in the Bay are formed by local winds and by the tidal surge, from 200-250°. In deep waters, the normal wave's amplitude is from 1.0m to 1.75m and a period of 10- 18 seconds, but this energy dissipates further in the Bay, and is less strong at the entrance to the Canal (the condition occurring every 100 years is 0.7m of amplitude with a 17s period). Local winds can form waves with an amplitude of ~1.0m and a ~4 second period during storms. Currents induced by the passage of a wave are strong in shallow waters, and, in combination with oceanic current and tide-induced currents could erode and transport the sediments existing the Bays' bed; this is an important consideration for the analysis of the final disposition of dredged material deposited at sea.

The ACP uses three sites for the disposal of dredged materials in this Zone, a shallow site at the entrance on the western side of the Canal and two other sites in deeper waters (~10m).

All the sewage from Panama City flow into this Bay untreated, although at this time there is plan for the future treatment of the sewage discharge (PB Consult, 2006) . Several studies have identified a high level of contamination in the Bay caused by the effects of these discharges, in clearer terms, by the fecal coliform concentrations and the oxygen demand on the water. High concentrations of carbon and nitrogen, with a fairly irregular distribution of metals closet o the coast, has been found in the sediments (ACP, 2006i), which is the final destination of most contaminants.

The islands of Taboga and Uraba are located in the southwestern sector of this Zone, part of which plus their immediate environment were designated as a wildlife refuge some 22 years ago, especially to protect the pelican birding sites. Beacuse of its beaches, for decades Taboga has been an important tourist destiny.

5.6 Protected Areas and Connectivity

This study conducted a revisión of the secondary sources relative to the Country's protected areas in general, and in particular, with those located along the route proposed for the Panama Canal. The literature reviewed for this subject was: Cabrera et al. (2006); Fundación NATURA (2006); Candanedo and Samudio (2005); CCAD-PNUD/GEF (2005); Amend and Almanza (2004); WMF (2003); ANAM (2003); Condit et al. (2001); ANAM (1999); GEF (1998); ANCON (1995); Vega (1994) and the National Environmental Authority (Autoridad Nacional del Ambiente) web page (www.anam.gob.pa). To facilitate their analysis, the information regarding the protected areas in the región was summarized and is presented in Figure 5-8 as well as in Table 5-48.

Among the protected areas of special interest for its proximity to the Project are the San Lorenzo Protector Forest and Protected Landscape, the Galeta Island Protected Landscape, the Gatun Lake recreational area, the Barro Colorado Island Natural Monument, the Soberania National Park, the Chagres National Park, the Las Cruces Trail National Park, and the Taboga and Uraba Wildlife Refuge. A significant portion of the land of the Panama Canal Watershed, which in this study corresponds to the General Study Area (AEG), is dedicated to the conservation of natural, historic, and cultural resources in protected areas; the number of areas dedicated to this function has increased with the years (Condit et al., 2001; ANAM, 1999; ANCON, 1995). The protected areas within the General Study Area (AEG) cover more than 10% of the Country's areas dedicated to conservation (Condit et al., 2001) (Figura 5-8).

It is worth mentioning that there are protected areas in the sectors adjacent to the specific study area (AEE) worth of being considered in this analysis because of their proximity to the Panama Canal entrances. On the other hand, there is a series of relatively small areas of conservation proposed by Law 21 of July 1997 on Interoceanic Region Territorial Ordinance, a few located in the central sector of the canal area, and others on the margins of Miraflores Lake and Alhajuela Lake, as well as Gatun Lake south of the José Dominador Bazán and Espinar residential areas (Amend and Almanza, 2004).

Upon considering the route of the Panama Canal Expansion Project – Third Set of Locks, we find, going from north to south, eight (8) protected areas in the specific study area (AEE), six

(6) of which are within the General Study Area (AEG) (Canal watershed), located in three different management categories (Figure 5-8; Table 5-53). In addition, the Summit Municipal Park, a center for the conservation of species administered by the Municipality of Panama, is also located there.

The creation of conservation units in the General Study Area (AEG) (Canal watershed) and its surrounding areas has been accomplished in a series of stages: beginning of Canal operations in the 1920s (Barro Colorado); start of the movement for the conservation of natural areas in the Country (Altos de Campana in 1966), the transfer of the first areas of the Canal Zone to Panamanian administration in the 80s (Soberania, Chagres, Gatun Lake, Metropolitan Natural Park), the transfer of the last Canal Zone area to Panamanian administration at the end of the last century (Las Cruces Trail in 1992, San Lorenzo and Galeta in 1997).

The Country's protected areas are regulated by the National Environmental Authority (Autoridad Nacional del Ambiente or ANAM) as provided by General Law of the Environment (Amend and Almanza, 2004). This Law confers ANAM the authority to award concessions for the management of protected areas basing the action on technical studies (ANAM, 1999). In this manner, seven (7) of the protected areas in the route under analysis are under ANAM's direct management, the other four (4) are under co-administrations designed by ANAM. The Smithsonian Tropical Research Institute (STRI) is the designated co-administrator of the Barro Colorado Island National Monument, a Foundation guides the conservancy efforts of the Metropolitan Natural Park (Amend and Almanza, 2004); there is an Interinstitutional Agreement for the administration and integral use of the San Lorenzo Protector Forest and Protected Landscape (ANAM, 2003); and several public institutions, universities and foundations, by means of an agreement, manage the conservation efforts at the Galeta Island Protected Landscape (CCAD-PNUD/GEF, 2005).

The personnel assigned to the tasks of conserving and managing the protected areas, in general, is insufficient and the numbers fluctuate regularly. Among the strategies used to strengthen the patrol personnel and control activities, work has been done in coordination with the Ecological

Police Division of the National Police, and special operations are carried out with officials from other protected areas on temporary loan to solve specific situations.

The training provided the personnel assigned to the protected areas is limited, thus affecting their ability to achieve an effective management of the areas (ANAM, 1999). Since monitoring the effectiveness of the management of these areas could drive the decision-making process to other administrative priorities, this tool has been used for the past ten years, and was legally adapted as the instrument to be used (Amend and Almanza, 2004). In addition, a program to follow-up the the monitoring of the effectiveness of management was established; thirty-five (35) protected areas in the Country participate in this program, including areas protected within the Canal watershed (AEG) (Cabrera et al., 2006).

The protected areas within the Canal watershed present a gradient in hunting activities, although they are more intense towards the Pacific Condit et al., 2001). The Soberania and Las Cruces Trail National Parks are under the greatest pressure since they are located closest to the largest populations (Condit et al., 2001); part of the Chagres National Park and the entire Soberania National Park are faced not only with subsistence hunting but also with sports hunting (ANAM, 1999). Although intensively patrolled and a well-equipped ranger team, the Barro Colorado Natural Monument is not devoid from eventual furtive hunters (Condit et al., 2001).

The informational and educational activities regarding the protected areas within the Canal watershed are conducted within the protected units, in buffer zones and in the communities that exist within parks and reserves. These are conducted not only by personnel assigned to protected areas, but also by other government offices and nongovernmental organizations. In this sense, worthy of mention is the effort conducted by the ACP to extend the environmental education messages to conservation of the natural resources of the region within the communities that inhabit the Canal watershed; and the Fondo Peregrino-Panama which disseminates information on the role and value of the birds of prey in the ecosystem, in particular the harpy eagle.

Nature tourism, a more recent activity in the región, has been fostered by several government entities, nongovernmental organization, and others. In recent years, organized teams of ecotourism guides have been formed, who actively participate in environmental education as well

as in the interpretation of nature in protected areas and neighboring areas. In this regard, the Barro Colorado National Monument Visitor Program stands out because of the high volume of persons visiting the monument each year as well as the training strategies and organization of the guides serving both local and foreign visitors.

Scientific investigations have been conducted in several of the protected areas, in particular at the Barro Colorado National Monument, where intensive long-term monitoring of the flora and fauna have been carried out (ANCON, 1995). The Soberania National Park as well as the Chagres National have also been the object of a series of studies. Of these parks the most used because of its accessibility is Soberania National Park where studies on flora and birds have been conducted (ANCON, 1995). More recently, the Las Cruces Trail National Park has been the object of vegetation studies (ANCON, 1995). However, it should be mentioned that this information is very seldom used as feedback for the management actions (ANAM, 1999). It is expected that the investigations in the Chagres areas increase slowly due to the recent approval a debt fund for nature between the governments of the United States and Panama. This fund will provide follow-up for a new type of management and development of a monitoring program of conservation objects at the Alto Chagres conservation site, which encompasses not only the Chagres National Park, but also part of the Portobelo National Park and the neighboring buffer zone (Fundación NATURA, 2006; Candanedo and Samudio, 2005).

Most of the Country's protected areas are inhabited; this occupation could have occurred either prior or after the establishment of the conservation area. In the region of the Panama Canal Expansion Project – Third Set of Locks (AEG), the areas with the largest population are the Chagres National Park, the Altos de Campana National Park, and the Portobelo National Park, each having a population of more than 1,500 persons within their limits (ANAM, 2003).

The funding for the conservation units managed directly by ANAM comes from the funds assigned to this government office mainly to cover salaries and basic operations; the Panama Ecological Trust provides resources for the strengthening of selected priority areas; and the Wildlife National Fund covers investment expenditures in the protected areas (Amend and Almanza, 2004). In addition, there is also a collection system in the protected areas for services

rendered to users; this includes, depending on the case: admission fees, lodging, camping, rent, and service concessions, guide services and other similar services, permits for commercial filming (Amend and Almanza, 2004). The protected areas in the Canal watershed have received international support on different occasions to finance certain planning, training, personnel equipment, and infrastructure construction, among others. The United States Agency for International Development (USAID) is one of the most recurrent donors.

There is a relative connectivity among these conservation units within the area of the Canal watershed and/or with neighboring sectors. Within the watershed this condition can be observed in the case of the Soberania National Park with the Las Cruces Trail National Park and the Metropolitan National Park (Condit et al., 2001) with a South – Southeast orientation. With other conservation units outside the Canal watershed, there are two cases linked to the Chagres National Park: with a North– South orientation is the connectivity between the Portobelo National Park and Chagres National Park; with a west – Northeast orientation is between the connectivity between the Nargana Corregimiento wildlife protected area in Kuna Yala (Candanedo and Samudio, 2005; WMF, 2003). Condit and collaborators (2001) discuss the North – South corridor comprised of vegetation areas with different levels of protection, and consider the cover gradient and the change of a semideciduous forest to an evergreen forest.

Aside from the local connectivity opportunities, the Country' Atlantic coast is part of a major effort to develop a corridor from the Panamanian Atlantic to connect Panama with Costa Rica and Colombia, and thus complete the Mesoamerican Biological Corridor (ANAM, 1999; GEF, 1998; Vega, 1994). The consolidation of the Mesoamerican Biological Corridor is a regional priority expressed in the Managua Statement subscribed by the Central American Environment Ministers (SICA, CCAD y CBM, 2005). In this sense, the conservation of each of the natural reserves of the region under analysis become more important because of their role as a crucial link in a long chain still under construction; in addition, the management of the landscapes found in the environments located between two natural reserves becomes a topic of great importance in order to facilitate connectivity.

As indicated in Table 5-48, four (4) of the eleven (11) protected areas cited herein are related to the area of direct impact (AID). The identified relation refers to the sectors neighboring Gatun Lake, or at the exist of the Chagres River toward this same lake, where the foreseen water level increase is expected to be reflected.

Table 5-49

Protected Areas in the Area of Study

Protected Area (year established)	Acreage (ha)	Management Documents (year)	Project Location		Comments
			Specific Interest	Direct Impact	
1- San Lorenzo Protector Forest and Protected Landscape(1997)	12,000	PM 2004 POE	Zone 1	-----	<ul style="list-style-type: none"> • Personnel = 6 • Investigations in different forest strata (STRI crane) • Historic resources from the colonial period and U.S. military occupation • Designated world cultural patrimony by UNESCO in 1980 • Declared endangered world cultural patrimony by WMF in 2000 • Coral reef in good condition
2- Galeta Island Protected Landscape	606	PM 2004	Zone 1	----	<ul style="list-style-type: none"> • Personnel = 5 • STRI investigations in coastal zone, mangroves, coral reefs • U.S. military occupation historic resources
3-Gatun Lake Recreational Area (1985)	348	PM 2004 POE	Zone 3	(yes)*	<ul style="list-style-type: none"> • Personnel = 6 •
4- Barro Colorado National Monument (1923, 1985)	5,400	Documentos guía	Zone 3	(yes)*	<ul style="list-style-type: none"> • Patches of flora for STRI long-term investigation • Aggressive visit and environmental education program
5- Soberania National Park (1980)	19,541	PM 2004, ee POE	Zone 3 Zone 4	(yes)*	<ul style="list-style-type: none"> • Personnel = 12 • Maximum diversity of birds (525 spp) and amphibians(62 spp) in the vegetal corridor on the Canal's east margin • Historic and cultural resources from the colonial period
6- Chagres National Park (1984)	129,585	P M 2004 POE	Zone 5	---	<ul style="list-style-type: none"> • Personnel = 34 • Monitoring of conservation objects via ANAM, ACP, SOMASPA, TNC and WCS since 2006
7- Portobelo National Park (1976)	35,929	PM 1994	---	---	<ul style="list-style-type: none"> • Personnel 6 • Designated world patrimony site by UNESCO in 1980. • Declared endangered world cultural patrimony site by WMF in 2000.

Protected Area (year established)	Acreage (ha)	Management Documents (year)	Project Location		Comments
			Specific Interest	Direct Impact	
8- Las Cruce Trail National Park (1992)	4,590	PM 2004 POE	Zone 5	(yes)*	<ul style="list-style-type: none"> • Vegetal patches for STRI investigation • Congregation and pernoctation site of migratory birds of prey
9- Metropolitan National Park (1985)	265	PM 1999, ee	Zone 6	---	<ul style="list-style-type: none"> • Personnel = 17 • Long-term investigation of occupants of the forest different strata via STRI
10- Altos de Campana National Park (1966)	4,925	PM 2004 POE	---	---	<ul style="list-style-type: none"> • Personnel = 9 • End of the Central Range
11- Taboga and Uraba Wildlife Refuge (1984)	258	PM	Zone 6	---	<ul style="list-style-type: none"> • Personnel = 2 • Pelican nesting islands • Remnants of coral reefs
Total: 11					

Notes: column 3: PM = management plan; POE = evaluated operation plan; ee = new management plan being edited; column 5: STRI = Smithsonian Tropical Research Institute; UNESCO = United Nations Educational, Scientific and Cultural Organization; WMF = World Monument Fund. *Relation with the area of direct impact (AID) by increase in the level of Gatun Lake.

Source: URS Holdings, Inc. Based on information from Cabrera et al., 2006; Amend and Almanza, 2004; Condit et al., 2001; Angehr and Jordán, 1998; and ANCON, 1995.