



# BIODIVERSITY ASSESSMENT STUDY FOR NEW CLARK CITY



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# PROJECT TEAM COMPOSITION



<b>Designation</b>	<b>Name</b>
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Entomologist	Prof. Juancho B. Balatibat, MSc
Project Coordinator	For. Gerald T. Eduarte, BSc

Cabanatuan City

Tarlac City

Capas

Mabalacat City

San Miguel

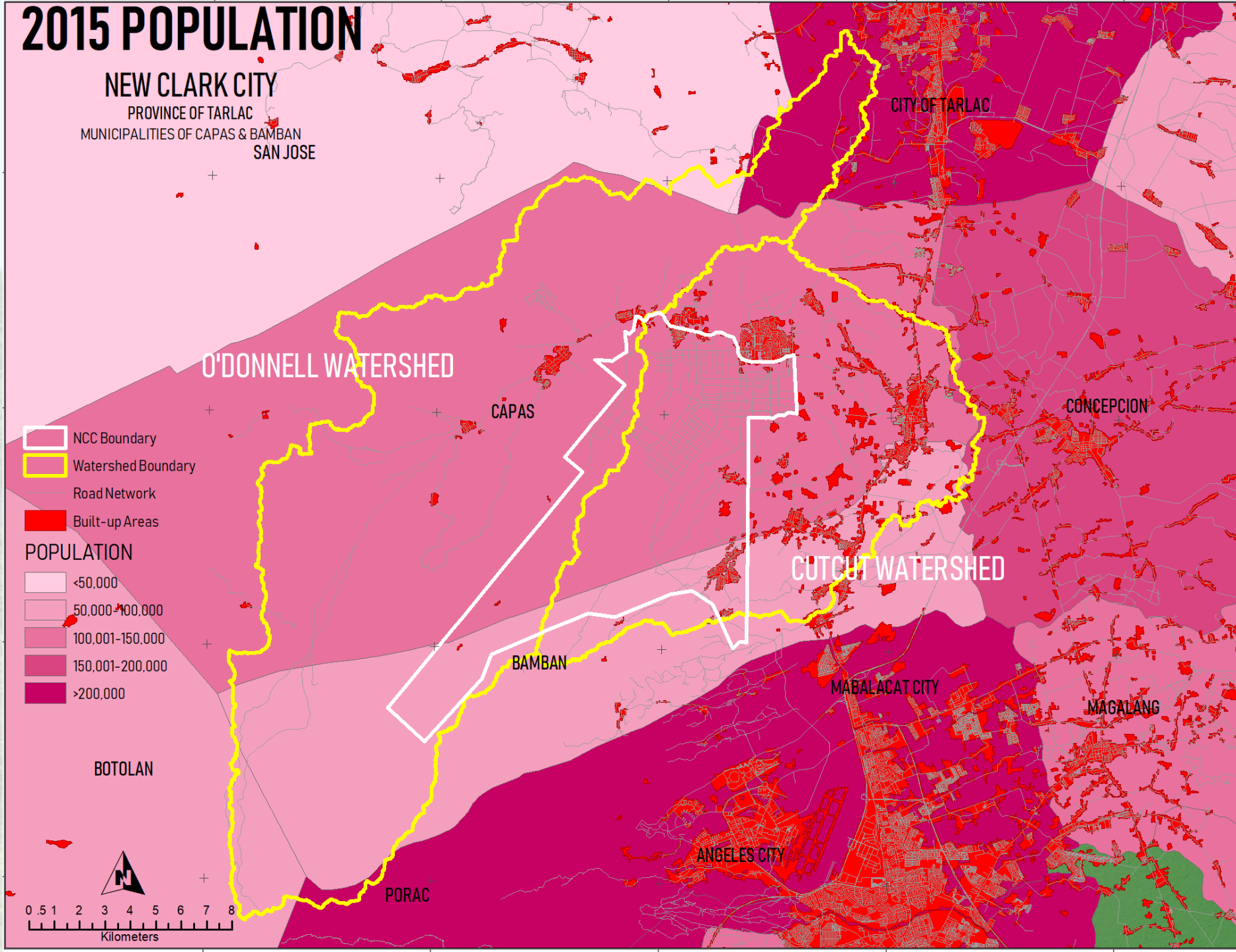
San Fernando



# 2015 POPULATION

## NEW CLARK CITY

PROVINCE OF TARLAC  
MUNICIPALITIES OF CAPAS & BAMBAN  
SAN JOSE



- NCC Boundary
- Watershed Boundary
- Road Network
- Built-up Areas

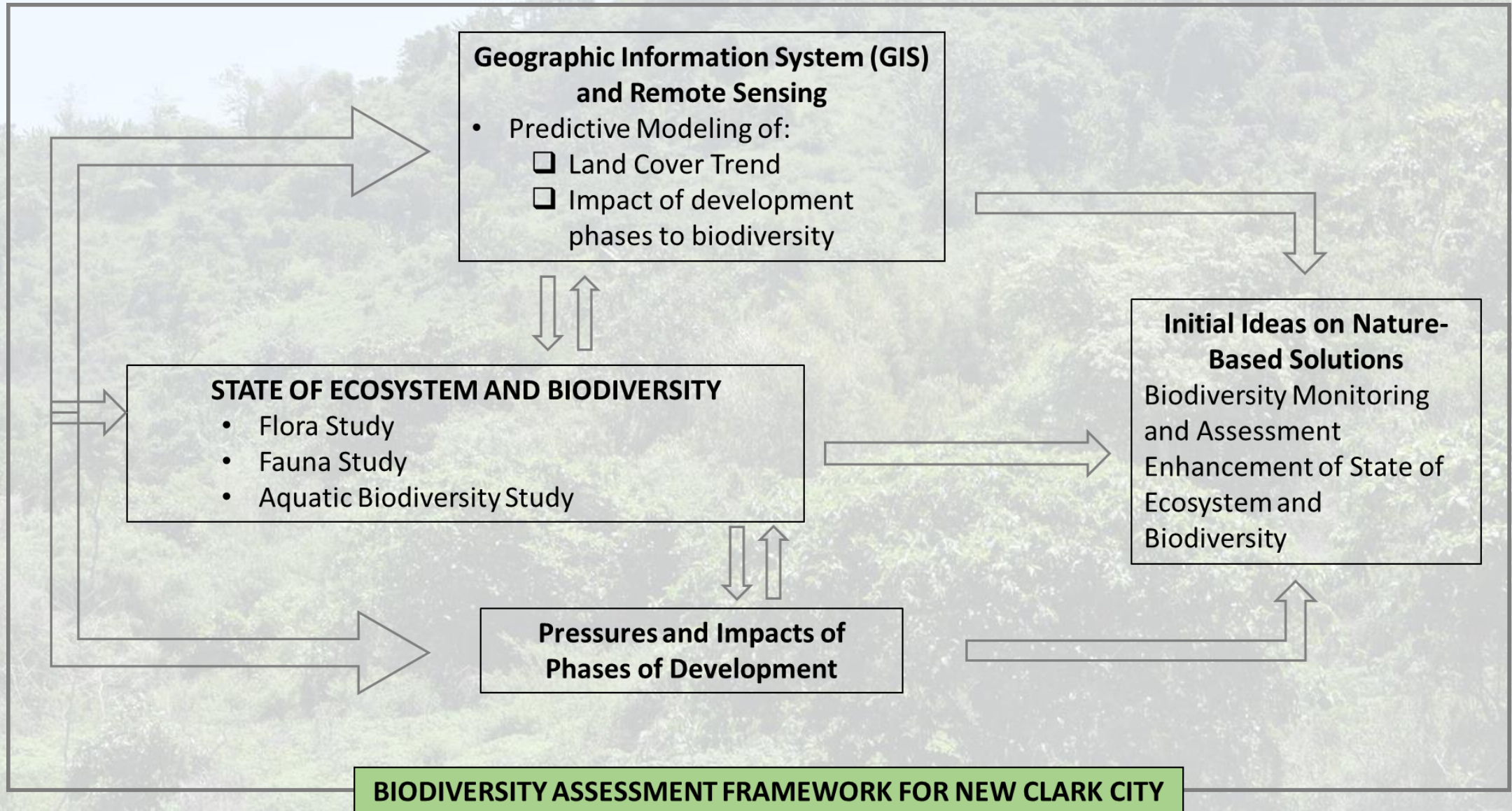
- POPULATION
- <50,000
  - 50,000-100,000
  - 100,001-150,000
  - 150,001-200,000
  - >200,000

# OBJECTIVES

Generate new scientific information to enable NCC build a foundation in developing nature-based solutions. Specifically:

1. Select sampling sites using GIS data and maps, reconnaissance survey, and information from locals;
2. Generate primary data of flora, fauna, and aquatic riverine ecosystem;
3. Analyze biodiversity and phase of urban development;
4. Provide recommendations on nature-based solutions; and
5. Provide recommendation on biodiversity monitoring systems suited for NCC

# BIODIVERSITY ASSESSMENT FRAMEWORK



# GENERAL METHODOLOGY

Selection of  
Sampling Sites

Site  
Reconnaissance

Field Survey

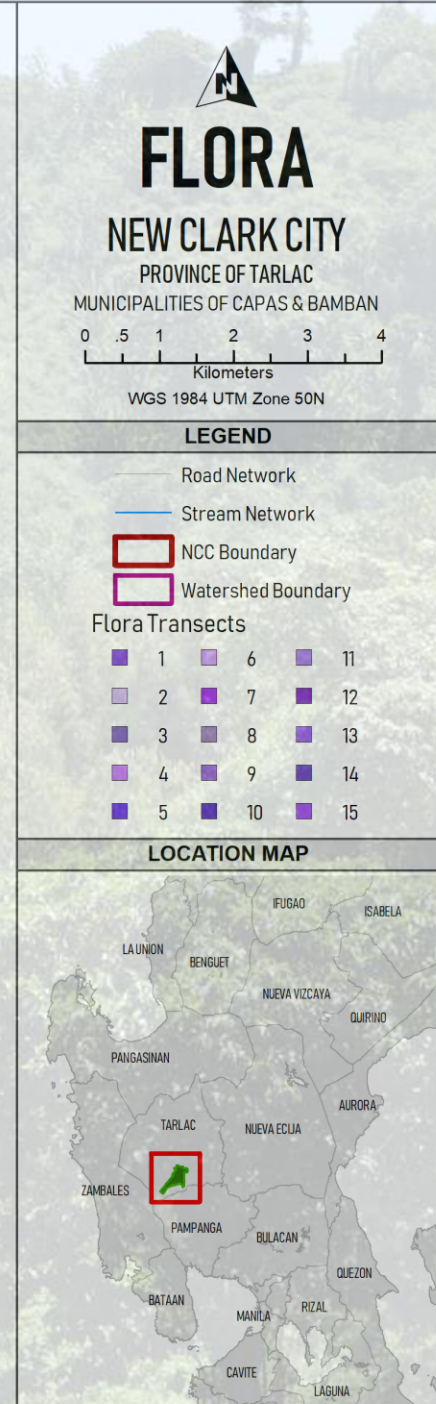
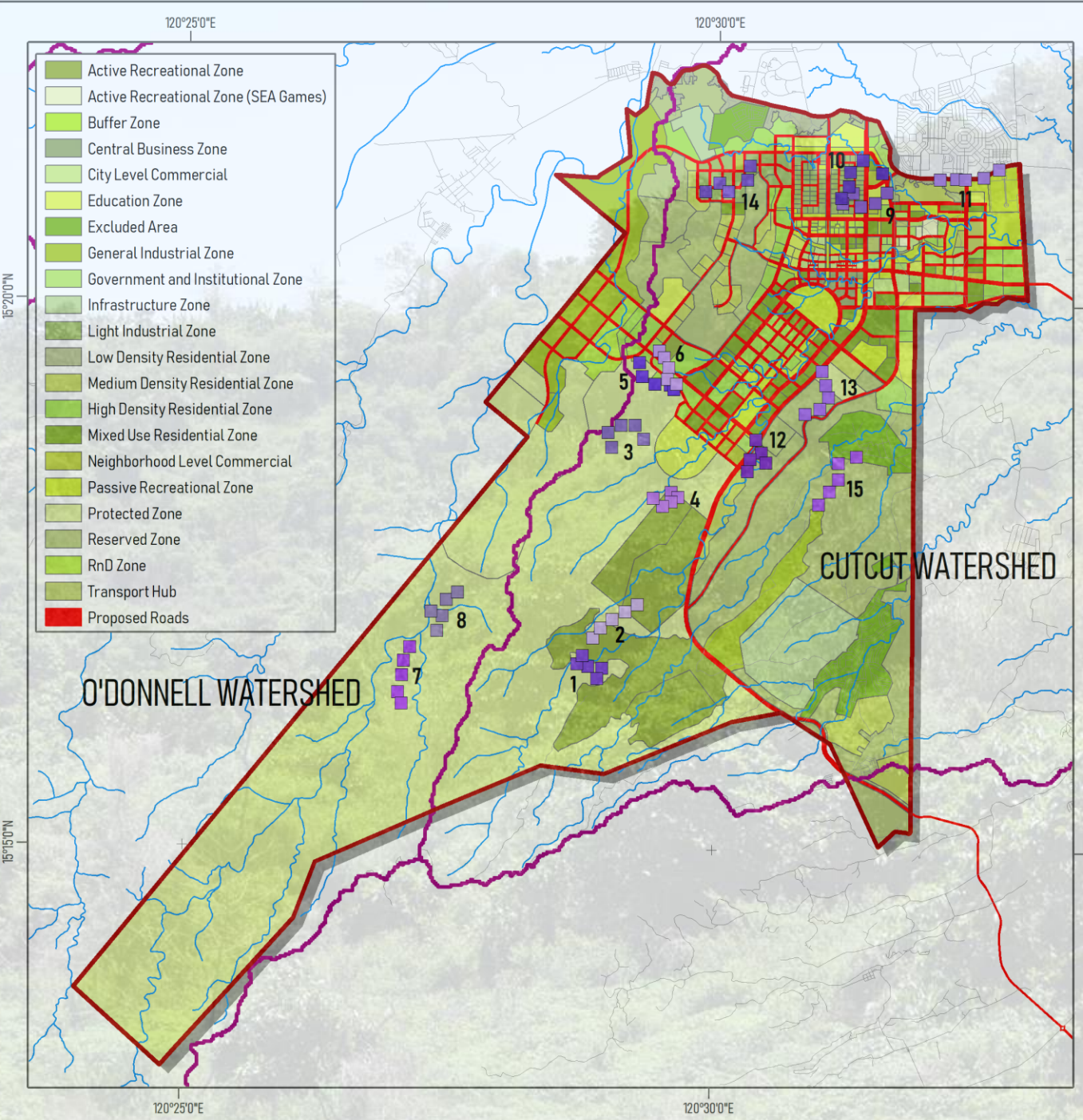
Data Analysis

Identification of  
Important  
Biodiversity  
Areas



# FLORAL DIVERSITY ASSESSMENT

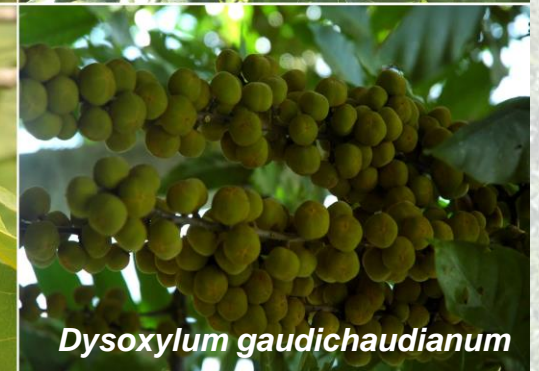




- ✓ 15 1-km modified belt transects
- ✓ 75 sampling quadrats (20m x 20m)

# Floristic Composition

- ✓ 276 morpho-species
- ✓ 112 genera
- ✓ 84 families
- ✓ Dominant Family:  
Fabaceae, Moraceae,  
Lauraceae, Meliaceae,  
Phyllantaceae, and Lamiaceae



# Floristic Composition

## *Tree Flora*

- ✓ 59 tree species
- ✓ 430 individuals
- ✓ 45 genera
- ✓ 24 families
- ✓ average density of about 0.015 tree/m<sup>2</sup> or 2 trees for every 100 m<sup>2</sup>



*Bauhinia malabarica*

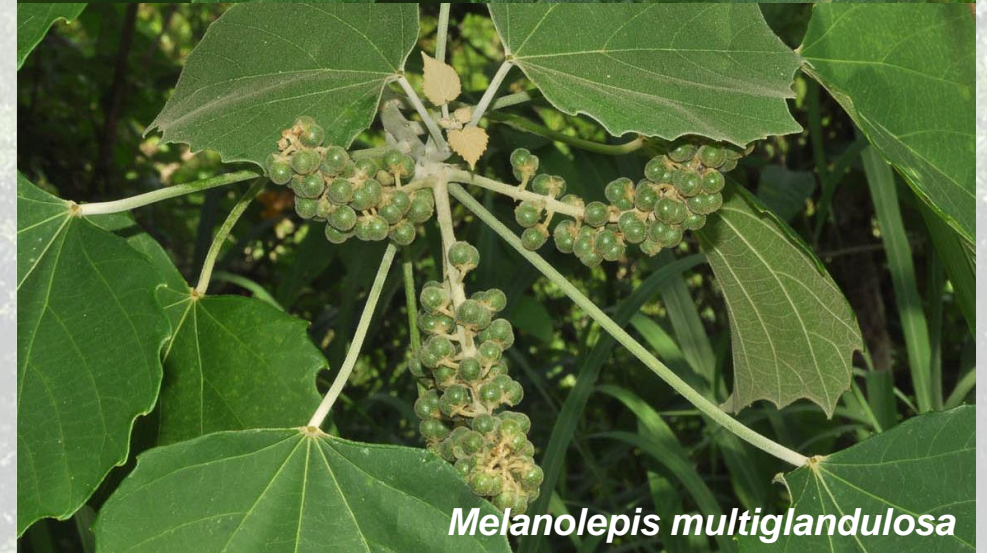
# Floristic Composition

## *Intermediate and Understorey*

- ✓ 74 morpho-species
- ✓ 677 individuals
- ✓ average density higher than of trees  
0.1128 individual/m<sup>2</sup> or 11 individuals  
per 100 m<sup>2</sup>
- ✓ Most abundant species are:  
*Lantana camara*, *Chromolaena odorata* and  
*Musa* sp.
- ✓ Most frequently occurring species are:  
*Melanolepis multiglandulosa* and  
*Macaranga tanarius*



*Lantana camara*

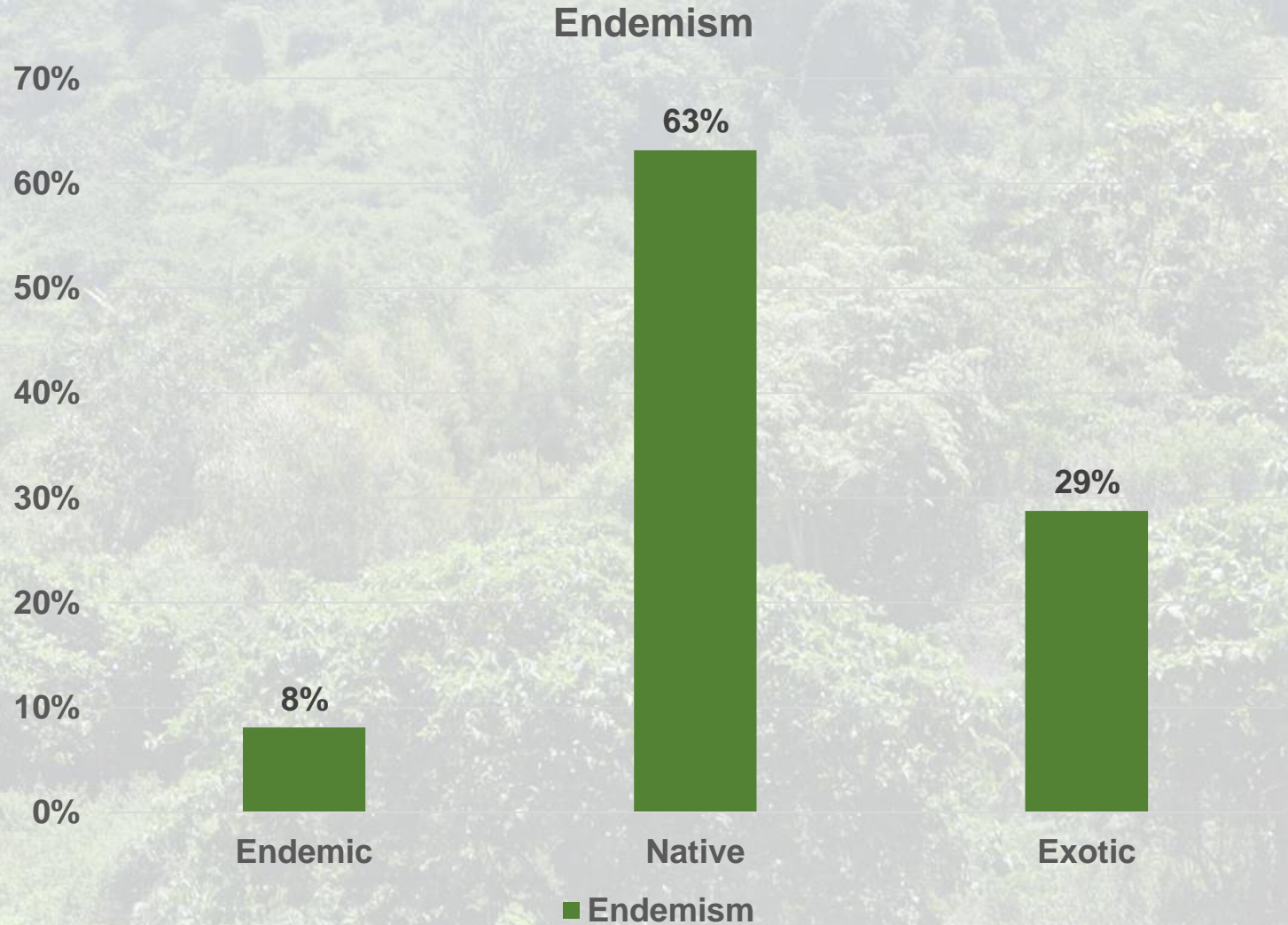


*Melanolepis multiglandulosa*

# Noteworthy Species

## *Endemic Species*

- ✓ 20 endemic species
- ✓ 156 native species
- ✓ 71 exotic species



# ENDEMIC SPECIES



**Malak-malak**  
*Palaquium philippense*



**Takulau**  
*Miliuma vidalii*

# ENDEMIC SPECIES



**White Lauan**  
*Shorea contorta*



**Bayoi**  
*Pterospermum obliquum*

**NOTEWORTHY SPECIES**

# ENDEMIC SPECIES



**Olod**  
*Cynometra inequifolia*



**Anabioin**  
*Artocarpus ovatus*

**NOTEWORTHY SPECIES**



# ENDEMIC SPECIES



**Kalulot**  
*Artocarpus rubrovenius*



**Pakiling**  
*Ficus odorata*

**NOTEWORTHY SPECIES**

# ENDEMIC SPECIES



**Niog-niogan**  
*Ficus pseudopalma*



**Alasas**  
*Ficus ulmifolia*

# ENDEMIC SPECIES



**Balakat**  
*Ziziphus talanae*



**Malaseresa**  
*Casearia fuliginosa*

**NOTEWORTHY SPECIES**

# ENDEMIC SPECIES



**Anolang**  
*Haplosticanthus lanceolatus*

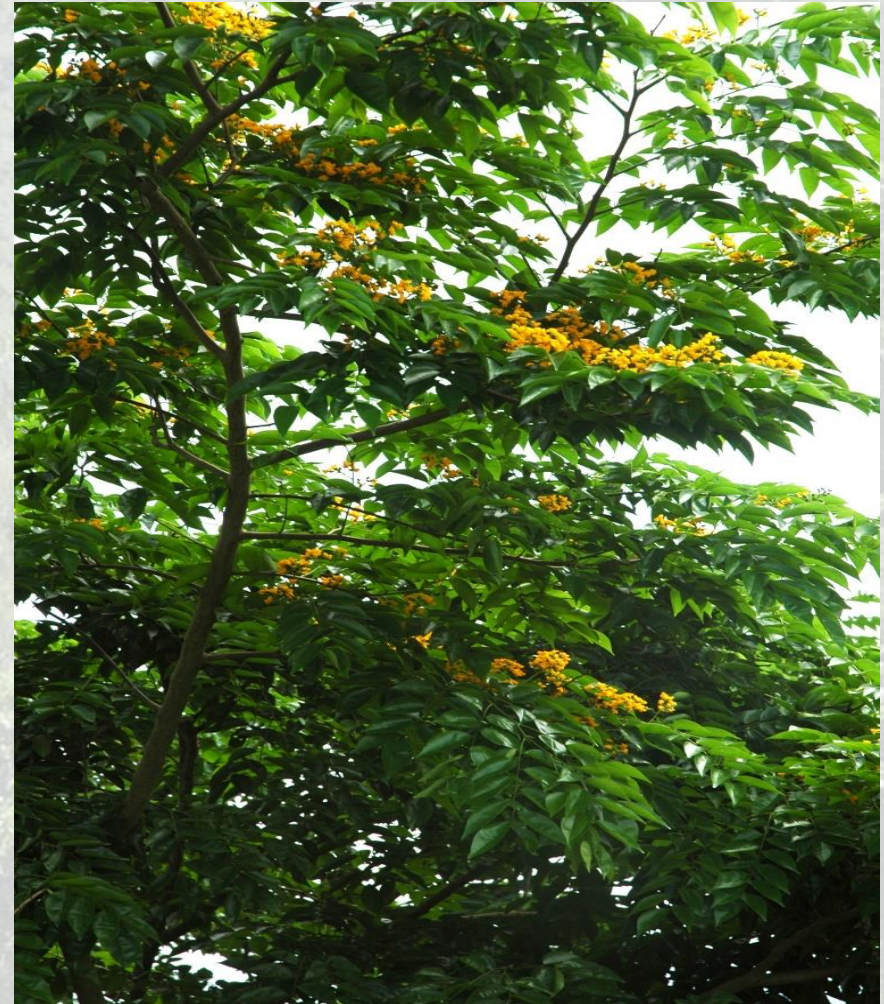
# THREATENED SPECIES



Panau

*Dipterocarpus gracilis*

Vulnerable (DAO 2017-11, IUCN 2019-1)



Daitanag

*Pterocarpus indicus*

Endangered (IUCN 2019-1)

# THREATENED SPECIES



**Molave**

*Vitex parviflora*

Endangered (DAO 2017-11)



**White Lauan**

*Shorea contorta*

Critically Endangered (IUCN 2019-1)

**NOTEWORTHY SPECIES**

# THREATENED SPECIES



**O-oi**  
*Diospyros philippinensis*  
Endangered (IUCN 2019-1)



**Bakauak-morado**  
*Clerodendrum quadriloculare*  
Vulnerable (DAO 2017-11)

**NOTEWORTHY SPECIES**

# New Province Records

- ✓ 40 morpho-species
- ✓ 36 genera
- ✓ 26 families





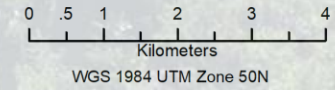
# Important Plant Areas

Transect	No. of Species	Ranking	No. of Endemic	Ranking	No. of Threatened	Ranking	Biodiversity Value
1	61	3	8	3	10	3	9
4	47	3	6	3	7	2	8
13	56	3	5	2	6	2	7
3	37	2	3	2	10	3	7
2	39	2	2	2	4	2	6
5	15	2	1	2	2	2	6
14	14	2	0	2	2	2	6
7	39	2	2	2	3	2	6
11	13	2	0	2	2	2	6
12	22	2	2	2	5	2	6
15	21	2	1	2	3	2	6
8	35	2	3	2	2	2	6
9	20	2	1	2	2	2	6
10	20	2	1	2	2	2	6
6	27	2	3	2	3	2	6

**Note:** The ranges used in ranking each criterion are the following: number of species (13 to 29 = 1, 30 to 45 = 2, 46 to 61 = 3); number of endemic species (0 to 1 = 1, 4 to 5 = 2, 6 to 8 = 3); and number of threatened species (2-5=1, 6-7=2, 8-10=3)

# FLORA

**NEW CLARK CITY**  
 PROVINCE OF TARLAC  
 MUNICIPALITIES OF CAPAS & BAMBAN



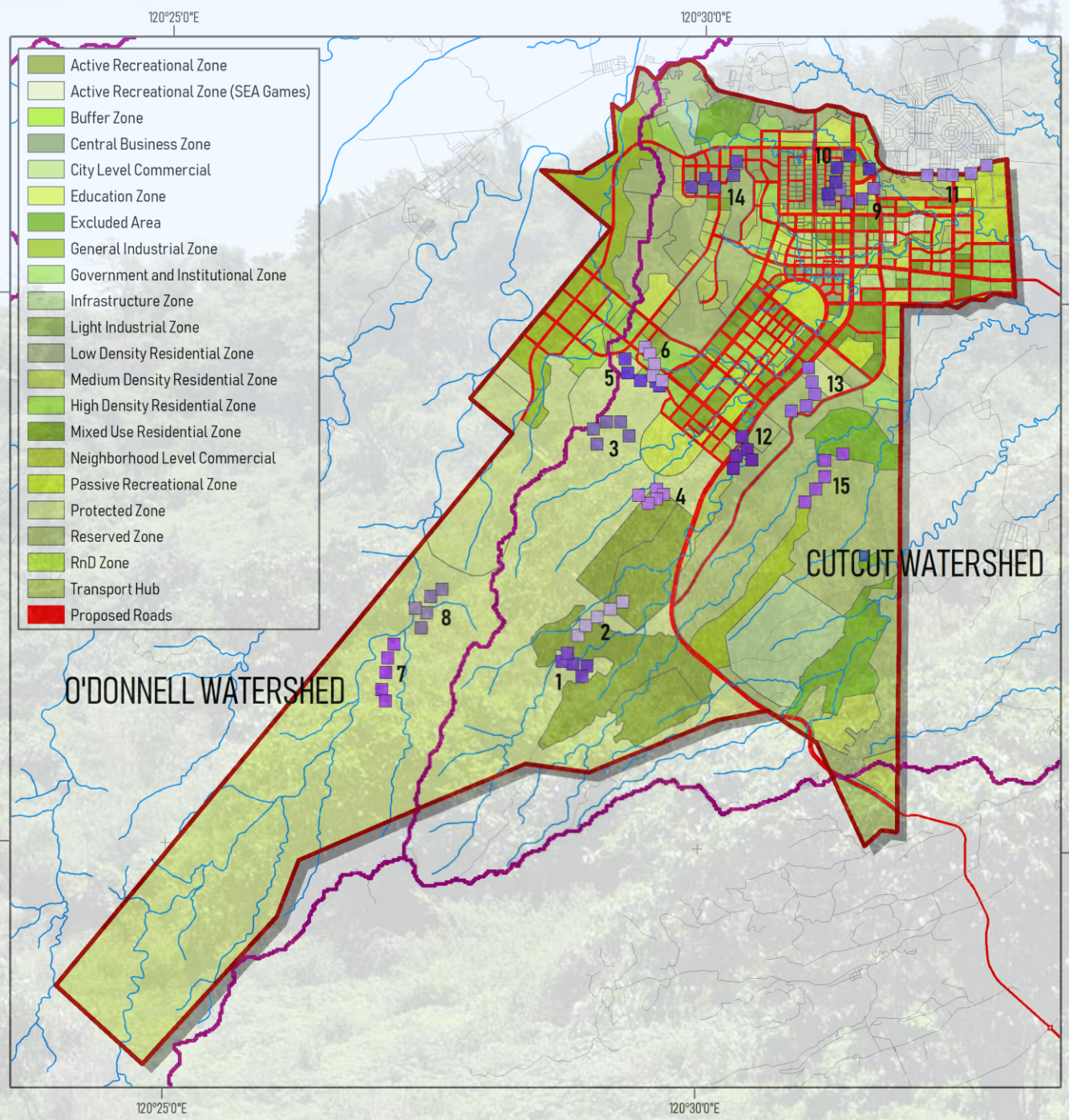
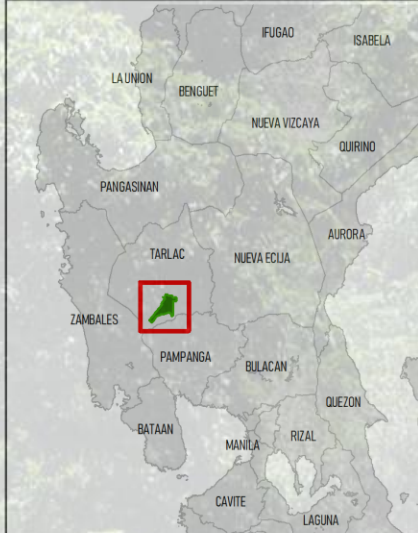
### LEGEND

- Road Network
- Stream Network
- NCC Boundary
- Watershed Boundary

### Flora Transects

- |   |    |    |
|---|----|----|
| 1 | 6  | 11 |
| 2 | 7  | 12 |
| 3 | 8  | 13 |
| 4 | 9  | 14 |
| 5 | 10 | 15 |

### LOCATION MAP



- Active Recreational Zone
- Active Recreational Zone (SEA Games)
- Buffer Zone
- Central Business Zone
- City Level Commercial
- Education Zone
- Excluded Area
- General Industrial Zone
- Government and Institutional Zone
- Infrastructure Zone
- Light Industrial Zone
- Low Density Residential Zone
- Medium Density Residential Zone
- High Density Residential Zone
- Mixed Use Residential Zone
- Neighborhood Level Commercial
- Passive Recreational Zone
- Protected Zone
- Reserved Zone
- RnD Zone
- Transport Hub
- Proposed Roads

# ALTERNATIVE NATIVE SPECIES FOR NCC



**Palosanto (Exotic)**  
*Triplaris cumingiana*



**Aunasin (Native)**  
*Ardisia pyramidalis*

# ALTERNATIVE NATIVE SPECIES FOR NCC



**Palosanto (Exotic)**  
*Triplaris cumingiana*



**Balitbitan (Native)**  
*Cynometra ramiflora*

# ALTERNATIVE NATIVE SPECIES FOR NCC



**Palosanto (Exotic)**  
*Triplaris cumingiana*



**Bagauak Morado (Native)**  
*Clerodendrum quadriloculare*

# ALTERNATIVE NATIVE SPECIES FOR NCC



**Champakang Puti (Exotic)**  
*Michelia alba*



**Katmon (Native)**  
*Dillenia philippinensis*

# ALTERNATIVE NATIVE SPECIES FOR NCC



**Kalachuchi (Exotic)**  
*Plumeria alba*



**Kahoy dalaga (Native)**  
*Mussaenda philippica*

# ALTERNATIVE NATIVE SPECIES FOR NCC



**Kalachuchi (Exotic)**  
*Plumeria alba*



**Lanete (Native)**  
*Wrightia pubscens* ssp. *laniti*



# ALTERNATIVE NATIVE SPECIES FOR NCC



**Foxtail Palm  
(Exotic)**  
*Woodyetia bifurcata*



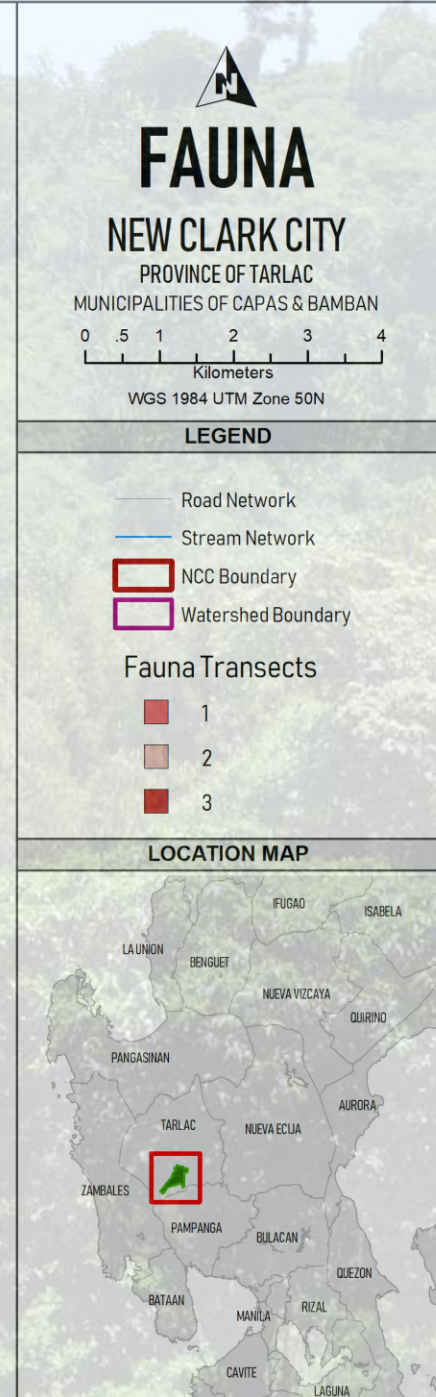
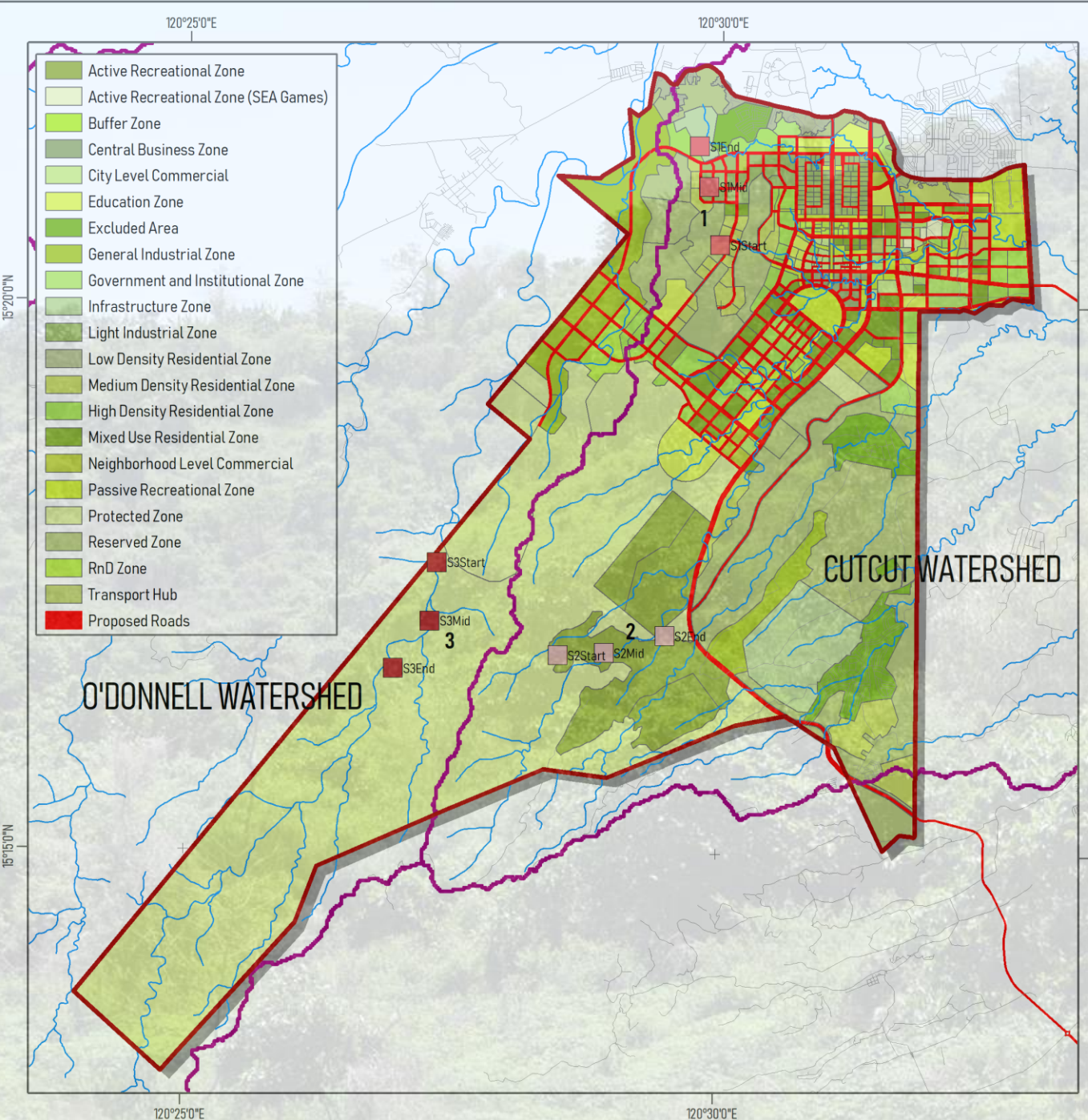
**Manila Palm  
(Native)**  
*Adonidia merrilii*

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# FAUNAL DIVERSITY ASSESSMENT *“Vertebrates”*

# NOTEWORTHY SPECIES

- **32 noteworthy species**
  - amphibians and reptiles – 6;
  - bird species – 21; and
  - mammals – 5
- Based on endemism and conservation status **78% are Philippine endemics**
- **5 endemic species are categorized as Threatened:**
  - *Naja philippinensis* (Philippine Cobra)
  - *Ninox philippensis* (Philippine Hawk-owl)
  - *Otus megalotis* (Philippine Scops Owl)
  - *Zoothera cinerea* (Ashy Ground Thrush)
  - *Sus philippensis* (Philippine Warty Pig)



- Site 1: Sitio Bukad-Baboy, Brgy. Sta Lucia, Capas, Tarlac
- Site 2: Sitio Canuman, Brgy. Dapdap, Bamban, Tarlac
- Site 3: Sitio Flora, Brgy. O'Donnell, Capas, Tarlac

- ✓ Three (3) 2-km transect
- ✓ 12 Mistnet stations
- ✓ 7 Traplines

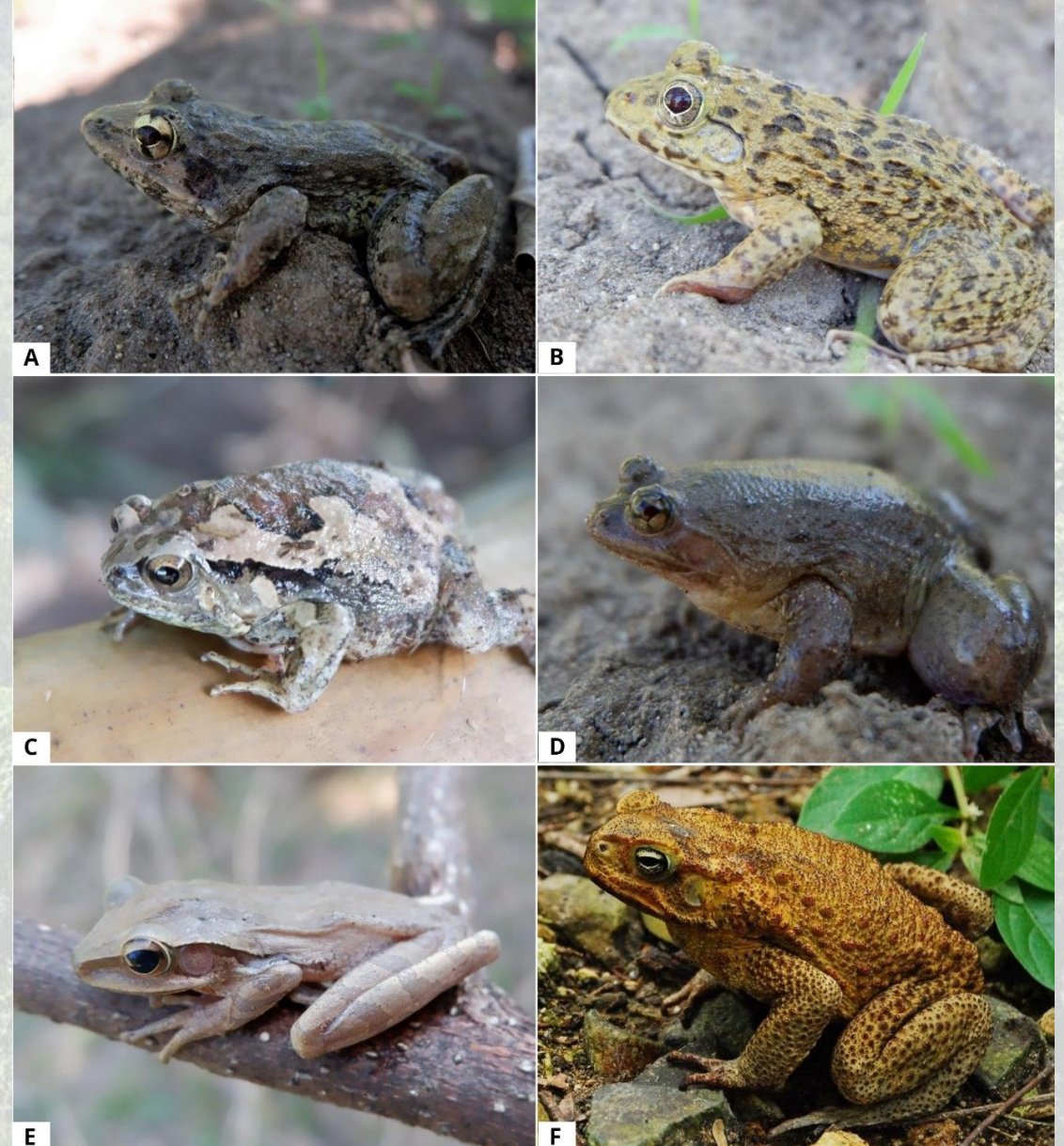
# RESULTS AND DISCUSSION

## Overall Diversity

Vertebrate Group	No. of Species Recorded
Amphibians	6
Reptiles	10 (5 lizards and 5 snakes)
Birds	77
Mammals	
Volant Mammals	6
Non-volant Mammals	7 (3 small mammals and 4 medium to large mammals)
<b>TOTAL</b>	<b>106</b>

# AMPHIBIANS

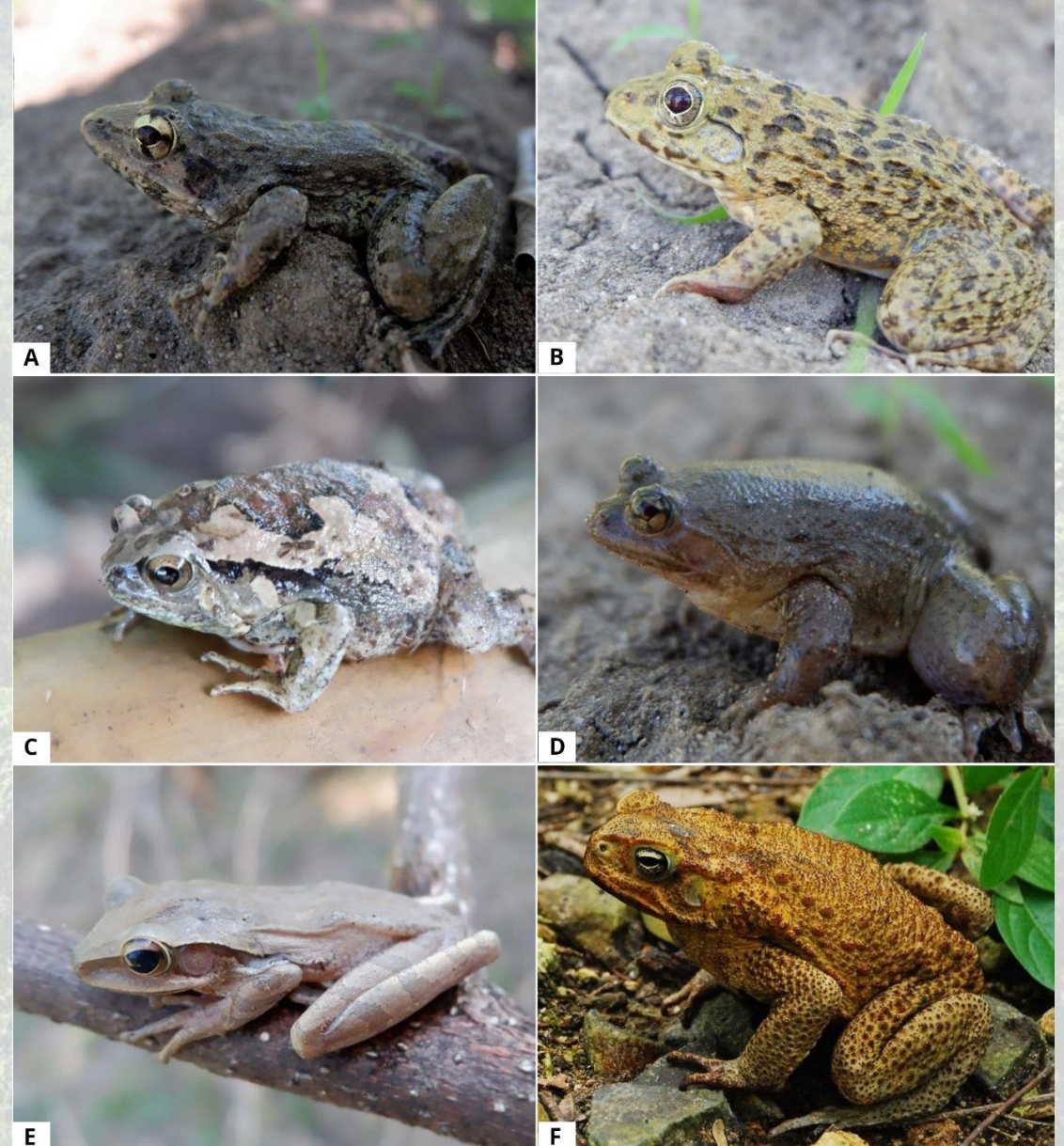
- No. of Species: 6
- No. of Families: 4
- 40% of recorded Tarlac amphibian fauna (iNaturalist.org)
- All recorded species are categorized as Least Concern under IUCN and DAO 2004-15.



# AMPHIBIANS

Selected photos of amphibians documented within the sampling sites:

- A – Asian brackish water frog (*Fejervarya cancrivora*)
- B – Taiwanese frog (*Hoplobatrachus rugulosus*)
- C – Slender-digit chorus frog (*Kaloula picta*)
- D – Common puddle frog (*Occidozygia laevis*)
- E – Common tree frog (*Polypedates leucomystax*)
- F – Giant marine toad (*Rhinella marina*)



# REPTILES

- No. of Species: 10
  - Lizards - 5
  - Snakes - 5
- No. of Families: 8
- 26% of recorded Tarlac reptilian fauna (iNaturalist.org)



A



B



# REPTILES

Selected photos of reptiles documented within the sampling sites:

**A** – Marbled crested lizard (*Bronchocela marmorata*)

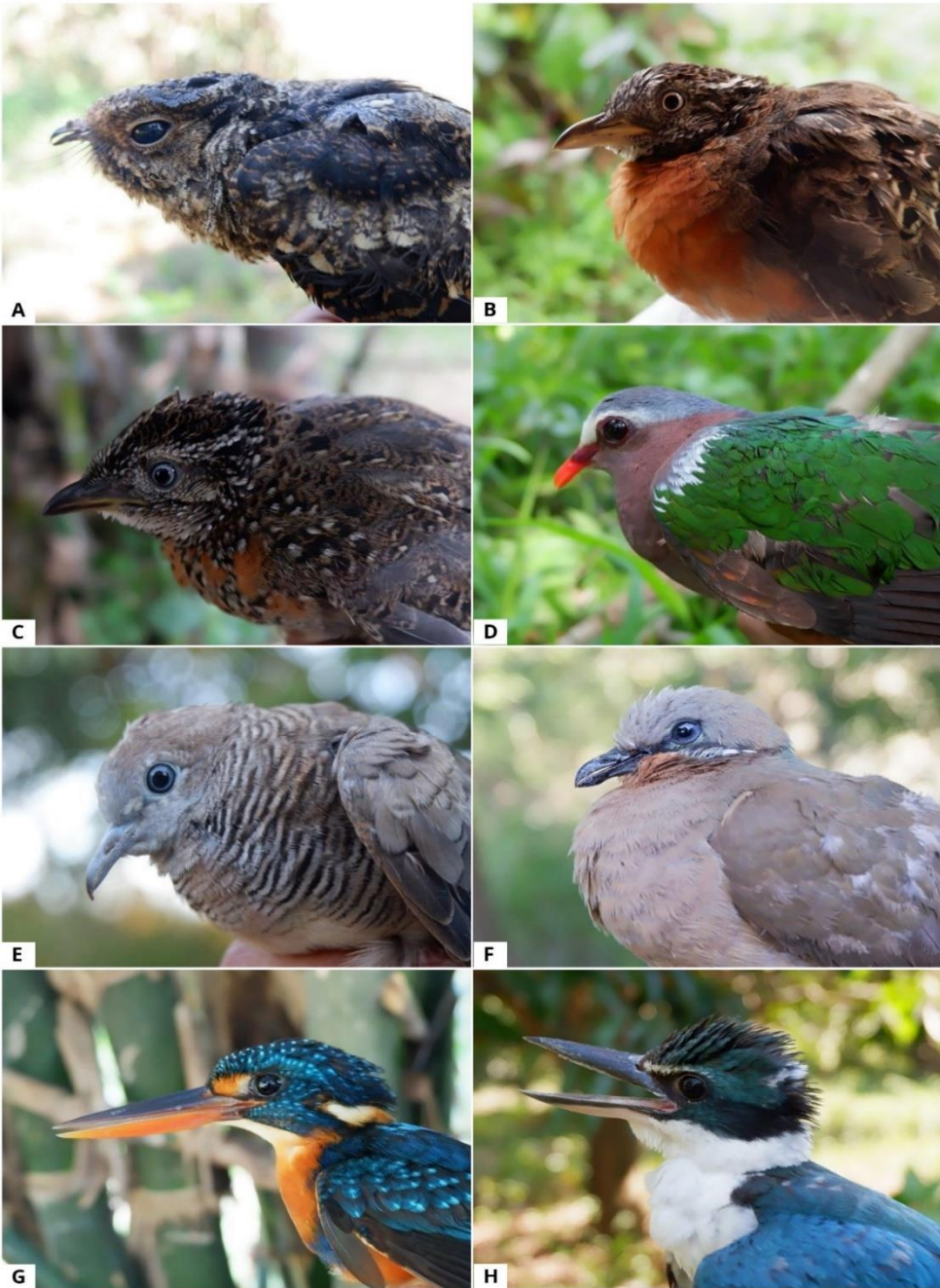
**B** – Tokay gecko (*Gekko gekko*)



# AVIAN FAUNA

- No. of Species: 77
- No. of Orders: 13
- No. of Families: 41
- 92% are recorded thru transect walk and 8% are recorded thru netting alone.
- 22% of recorded Tarlac avian fauna ([Avibase.bsc-eoc.org](http://Avibase.bsc-eoc.org))





Selected photos of avifauna documented within the sampling sites:

- A** – Philippine nightjar (*Caprimulgus manillensis*)
- B** – Spotted buttonquail (*Turnix ocellata*)
- C** – Barred buttonquail (*Turnix suscitator*)
- D** – Common emerald dove (*Chalcophaps indica*)
- E** – Zebra dove (*Geopelia striata*)
- F** – White-eared brown dove (*Phapitreron leucotis*)
- G** – Indigo-banded kingfisher (*Alcedo cyanopecta*)
- H** – White-collared kingfisher (*Halycon chloris*)



I



J



K



L



M



N



O



P

Selected photos of avifauna documented within the sampling sites:

**I** – White-throated kingfisher (*Halcyon smyrnensis*)

**J** – Philippine coucal (*Centropus viridis*)

**K** – Philippine hawk-cuckoo (*Cuculus fugax*)

**L** – Large-billed crow (*Corvus macrorhynchos*)

**M** – Mangrove blue flycatcher (*Cyornis rufigastra*)

**N** – Golden-bellied fly eater (*Gerygone sulphurea*)

**O** – Philippine bulbul (*Hypsipetes philippinus*)

**P** – Brown shrike (*Lanius cristatus*)



Q



R



Y



Z



S



T



U



V



W

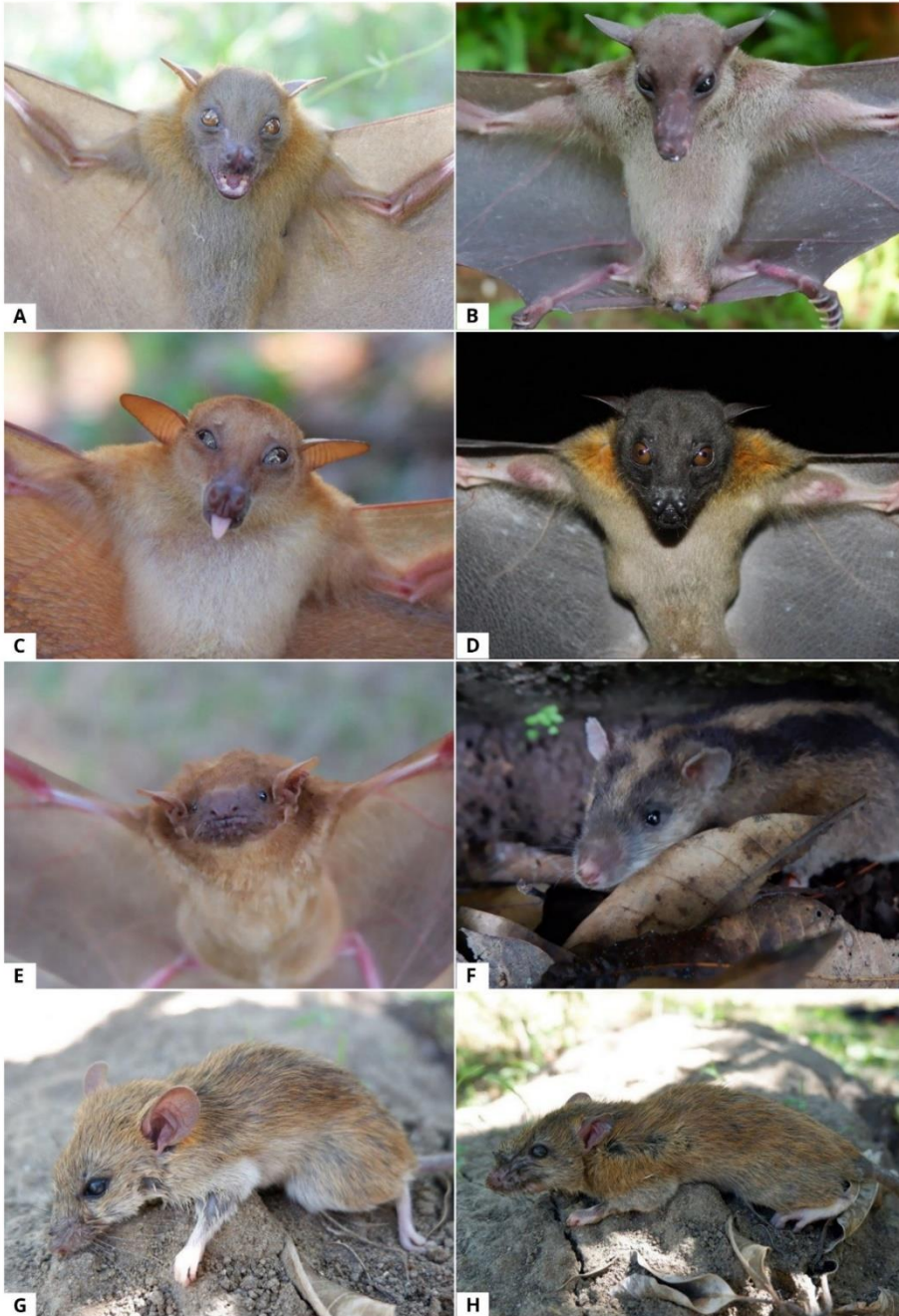


X

- Selected photos of avifauna documented within the sampling sites:
- Q – Long-tailed shrike (*Lanius schach*)
  - R – Striated grassbird (*Megalurus palustris*)
  - S – Hooded pitta (*Pitta sordida*)
  - T – Yellow-vented bulbul (*Pycnonotus goiavier*)
  - U – Philippine pied fantail (*Rhipidura javanica*)
  - V – Ashy ground thrush (*Zoothera cinerea*)
  - W – Black-crowned night heron (*Nycticorax nycticorax*)
  - X – Luzon hawk-owl (*Ninox philippensis*)
  - Y – Philippine scops owl (*Otus megalotis*)
  - Z – Grass owl (*Tyto capensis*)

# MAMMALS

- No. of Species: 13
  - Volant Mammals - 6
  - Non-volant Mammals- 7
- No. of Orders: 5
- No. of Families: 6
- 25% of recorded Tarlac mammalian fauna (iNaturalist.org)



Selected photos of mammals documented within the sampling sites:

**A** – Common short-nosed fruit bat (*Cynopterus brachyotis*)

**B** – Common dawn bat (*Eonycteris spelaea*)

**C** – Lesser long-tongued fruit bat (*Macroglossus minimus*)

**D** – Greater musky fruit bat (*Ptenochirus jagori*)

**E** – Lesser asiatic yellow house bat (*Scotophilus kuhli*)

**F** – Lowland striped shrew rat (*Chrotomys mindorensis*)

**G** – Polynesian rat (*Rattus exulans*)

**H** – Oriental house rat (*Rattus tanezumi*)

# IMPORTANT WILDLIFE AREAS

- Site 2 (Sitio Canuman, Brgy. Dapdap)
  - High number of endemic and threatened wildlife species
  - Presence of forest fragments
- Site 3 (Sitio Flora, Brgy. O'Donnell)
  - Wetland-associated species and migratory birds



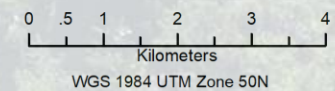




# FAUNA

## NEW CLARK CITY

PROVINCE OF TARLAC  
MUNICIPALITIES OF CAPAS & BAMBAN



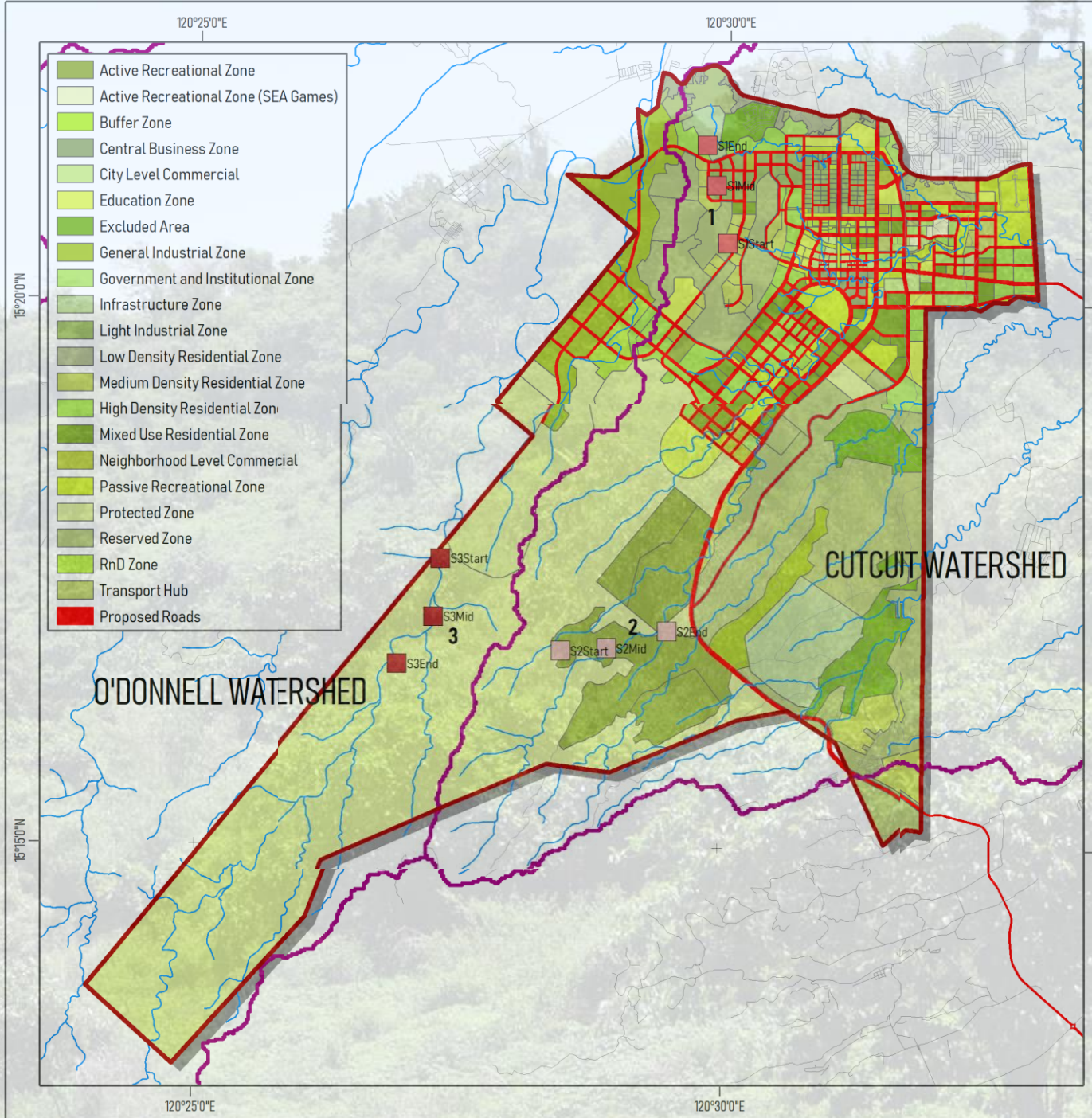
### LEGEND

- Road Network
- Stream Network
- NCC Boundary
- Watershed Boundary

### Fauna Transects

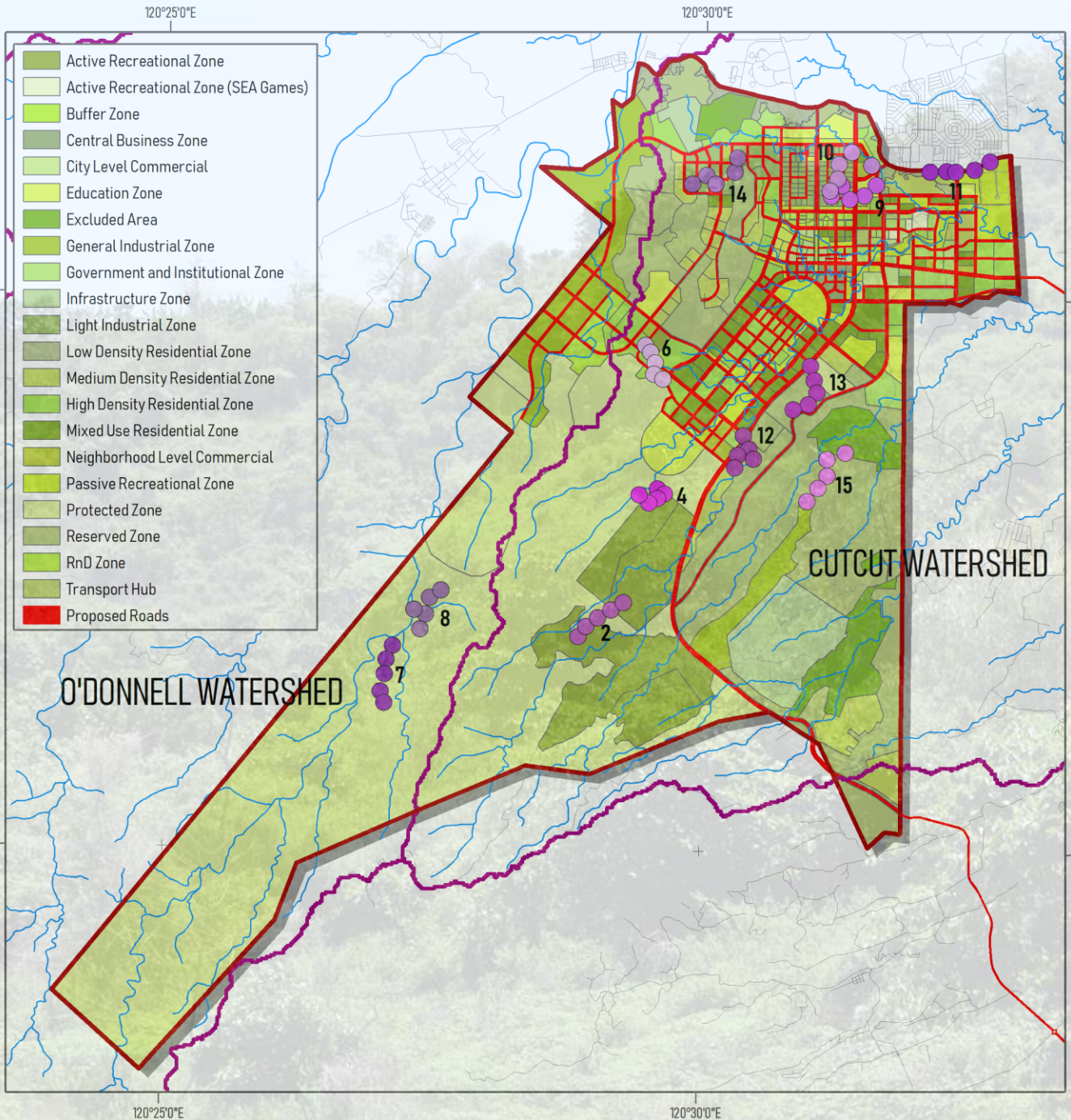
- 1
- 2
- 3

### LOCATION MAP



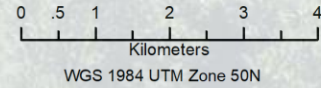
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- Transport Hub
- Proposed Roads

# FAUNAL DIVERSITY ASSESSMENT *“Invertebrates”*



# ARTHROPODS

NEW CLARK CITY  
 PROVINCE OF TARLAC  
 MUNICIPALITIES OF CAPAS & BAMBAN



### LEGEND

- Road Network
- Stream Network
- NCC Boundary
- Watershed Boundary

### Arthropod Transects

- |  |  |  |
|--|--|--|
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

### LOCATION MAP



- ✓ 12 1-km modified belt transects
- ✓ 65 sampling quadrats



Left: **Net sweeping technique** used to collect arthropod fauna from the sampling plots; right – **glass jar** for killing and preserving arthropod specimens

# Invertebrate Fauna

## *Arthropod Composition and Abundance*

- **111 arthropod species** representing Class Insecta and Class Arachnida
- **9 orders**
- **68 families**

### **Class Insecta**

- ❑ 103 species
- ❑ 8 orders
- ❑ 62 families

### **Class Arachnida**

- ❑ 8 species
- ❑ 1 order
- ❑ 6 families

# Order Odonata (Dragonflies)



**Chalky Percher**  
(*Diplacodes trivialis*)



**Crimson-tailed Marsh Hawk, female**  
(*Orthetrum pruinatum*)

**Straight-edged Red Parasol, male**  
(*Neurothemis terminata*)



**Crimson-tailed Marsh Hawk, male** (*Orthetrum pruinatum*)



# Order Odonata (Dragonflies)



**Green Marsh Hawk**  
(*Orthetrum sabina*)



**Crimson Marsh Glider**  
(*Tritemis aurorae*)

# Order Lepidoptera (Butterflies)



**Typical Sailer**  
**(*Neptis mindorana*)**



**Luzon Grass Dart**  
**(*Taractrocera luzonensis*)**



# Order Lepidoptera (Moths)



**Wasp Moth**  
(*Amata huebneri*)



**Pyralid moth**

# Other Insects



**Molted cuticle of cicada**



**Colony of weaver ant (*Oecophylla smaragdina*)**

# Other Insects

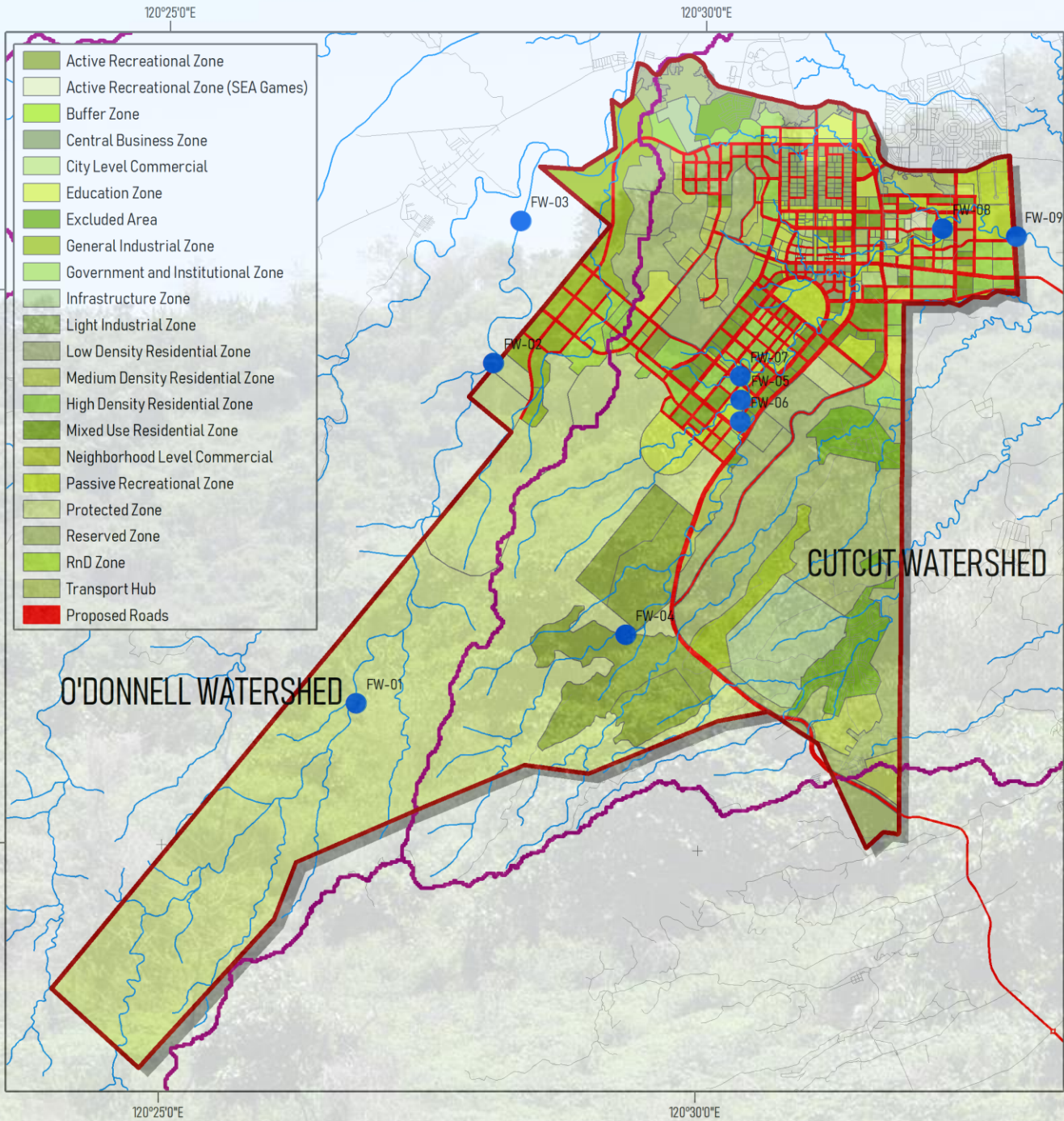


**Group of mango hopper,  
*Idioscopus* sp.**



**Common housefly (*Musca domestica*)**

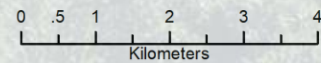
# FRESHWATER ECOLOGY ASSESSMENT



# FRESHWATER

## NEW CLARK CITY

PROVINCE OF TARLAC  
MUNICIPALITIES OF CAPAS & BAMBAN



WGS 1984 UTM Zone 50N

### LEGEND

- Road Network
- Stream Network
- NCC Boundary
- Watershed Boundary
- Freshwater Sampling Point

### LOCATION MAP



✓ 9 Sampling Freshwater sampling stations

# Freshwater Ecology

## *Dominant Periphyton*



*Synedra* sp. (100x magnification)

# Freshwater Ecology

## *Dominant Periphyton*



*Spirogyra* sp. (100x magnification)

# Freshwater Ecology

## *Dominant Periphyton*

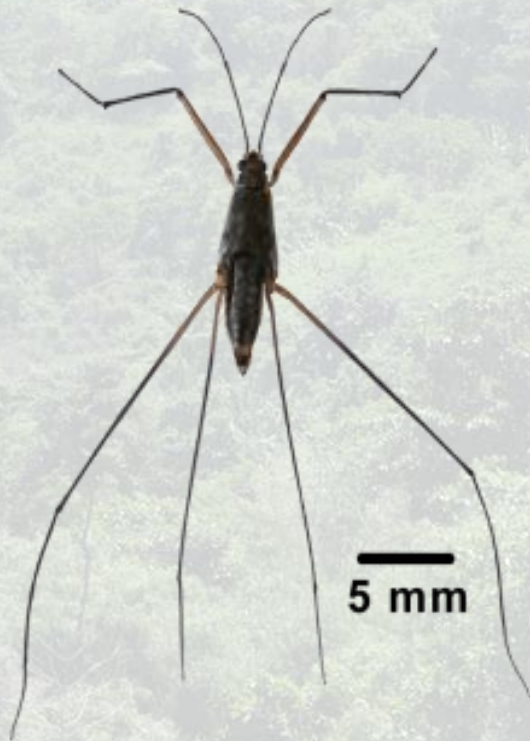


*Fragilaria* sp. (100x magnification)



# Freshwater Ecology

*Macrobenthos: Dominant macroinvertebrates*



Order Hemiptera  
Family Gerridae  
water strider, *Gerris* sp.



Order Decapoda  
Family Palaemonidae  
freshwater prawn, *Macrobrachium latidactylus*

# Freshwater Ecology

*Macrobenthos: Dominant macroinvertebrates*



Order Ephemeroptera  
Family Ephemeridae  
spiny crawler mayfly, *Ephemerella* sp.



Order Odonata  
Family Coenagrionidae  
forktail damselfly, *Ischnura* sp.

# Freshwater Ecology

*Macrobenthos: Dominant macroinvertebrates*



5 mm

Order Venerida  
Family Cyrenidae  
*Asian clam, Corbicula fluminea*

# Freshwater Ecology

## *Noteworthy Species*



Order Decapoda

Family Potamidae

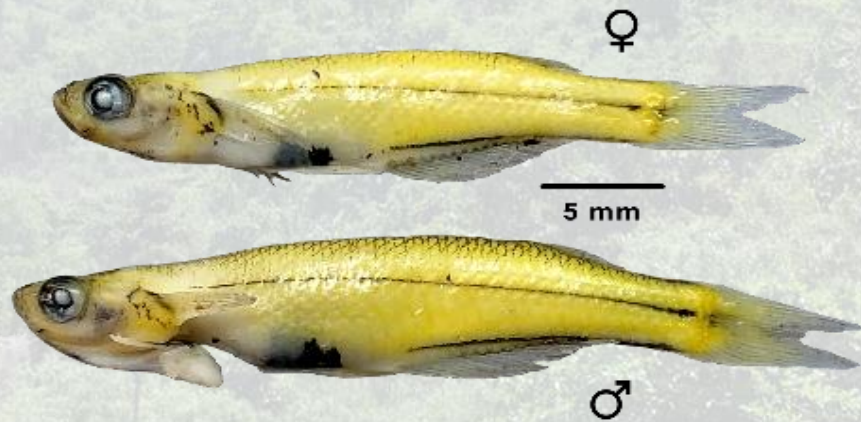
Riverine crab, *Sundathelphusa grapsoides*

# Freshwater Ecology

## *Fish*

- ❑ 12 fish species
- ❑ 934 individuals
- ❑ 11 families
- ❑ Philippine endemic species:
  - priapium fish, *Gulaphallus mirabilis*
  - freshwater halfbeak, *Nomorhamphus pectoralis*
  - freshwater halfbeak, *Zenarchopterus philippinus*

# Endemic Species



**Priapium fish**  
***Gulaphallus mirabilis***



**Freshwater halfbeak**  
***Nomorhamphus pectoralis***

# Endemic Species



Freshwater halfbeak  
*Zenarchopterus philippinus*

# Native Species



**Walking catfish**  
*Clarias batrachus*



**Rock goby**  
*Glossogobius illimis*



# Introduced Species

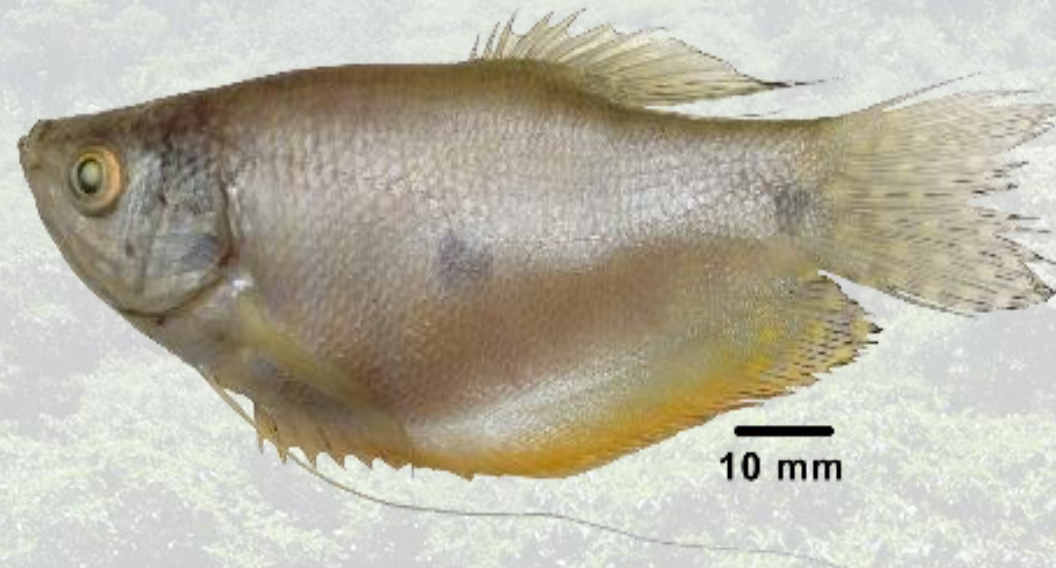


**Wild goldfish**  
***Carassius auratus***



**Snakehead murrel**  
***Channa striata***

# Introduced Species



**Three-spot gourami**  
*Trichopodus trichopterus*

# Invasive Alien Species (IAS)



5 mm



**Wild guppy**  
*Poecilia reticulata*

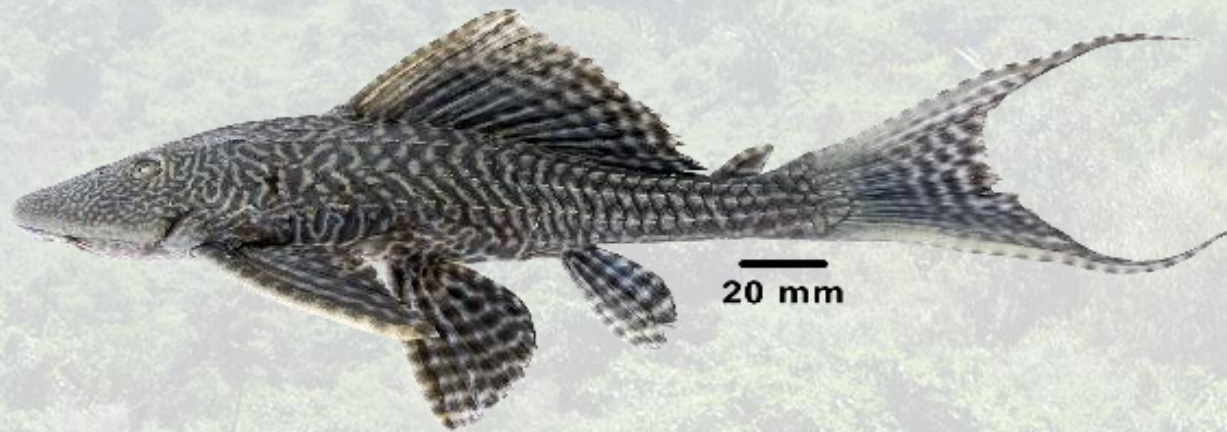


5 mm



**Wild molly**  
*Poecilia sphenops*

# Invasive Alien Species (IAS)



**Janitor fish**  
*Pterygoplichthys pardalis*



**Nile tilapia**  
*Oreochromis niloticus*

# Reptile

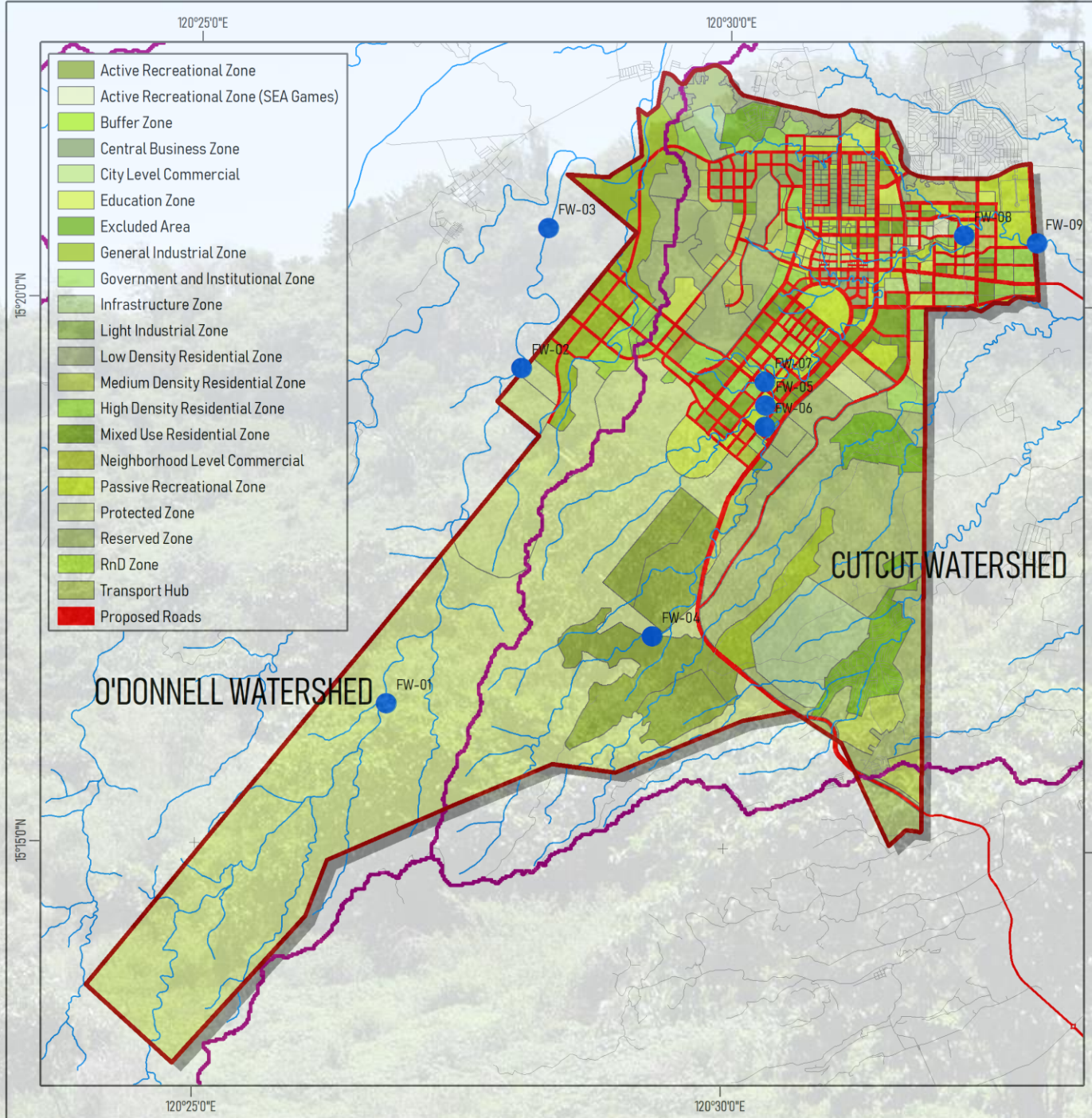


**Chinese soft shell turtle**  
*Pelodiscus sinensis*

# IMPORTANT FRESHWATER AREAS

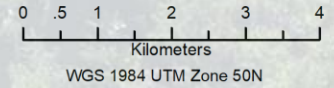
- FW-04
  - Hosts **17 macroinvertebrate species, 2 endemic and 2 native freshwater fishes.**
- FW-06
  - Hosts **10 macroinvertebrate species, 2 endemic and 1 native freshwater fish.**





# FRESHWATER

**NEW CLARK CITY**  
 PROVINCE OF TARLAC  
 MUNICIPALITIES OF CAPAS & BAMBAN



### LEGEND

- Road Network
- Stream Network
- NCC Boundary
- Watershed Boundary
- Freshwater Sampling Point

### LOCATION MAP



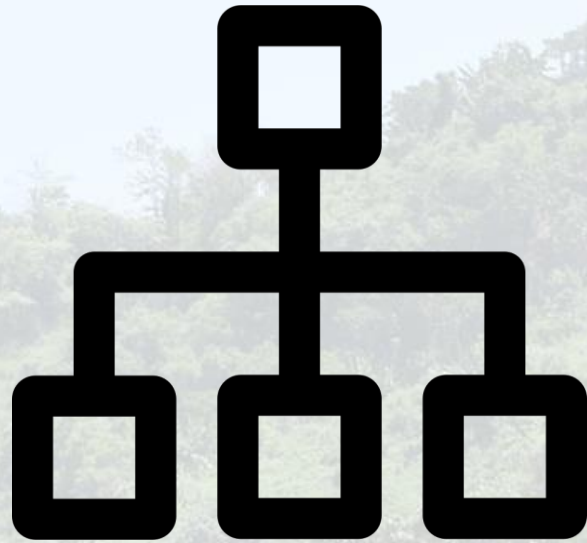
# MODELLING URBAN LAND USE CHANGE & SAMPLE GEODATABASE



# MODELLING URBAN LANDUSE CHANGE



1



2

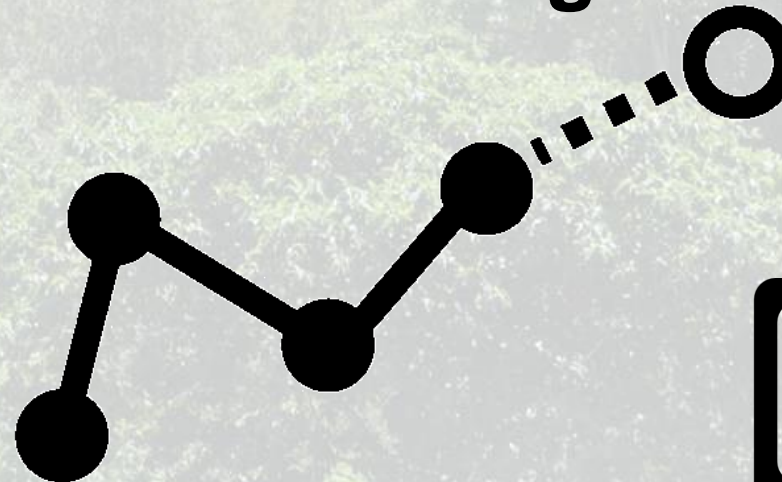


Image Classification and Cover Change Analysis

3

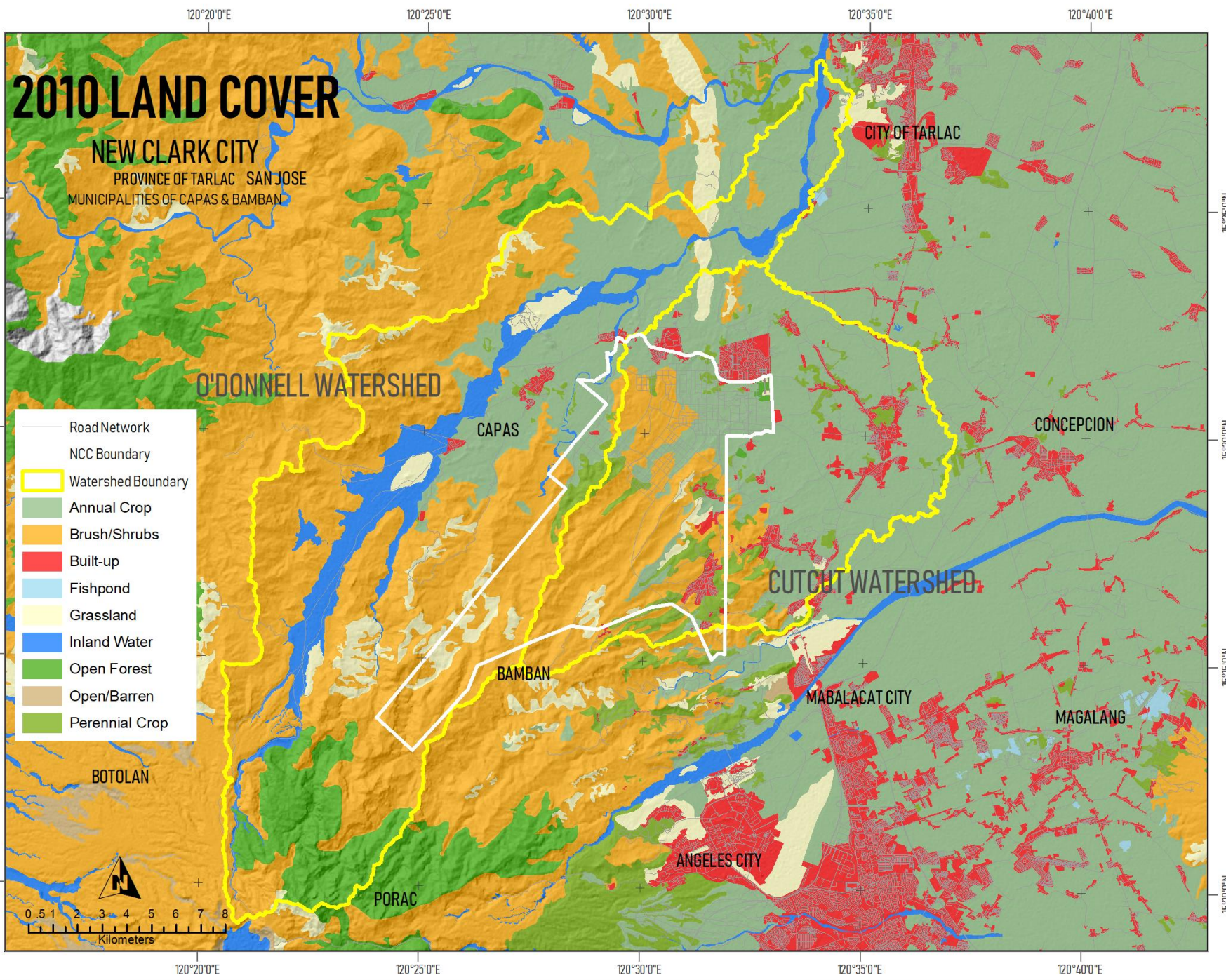


Transition Potential



4

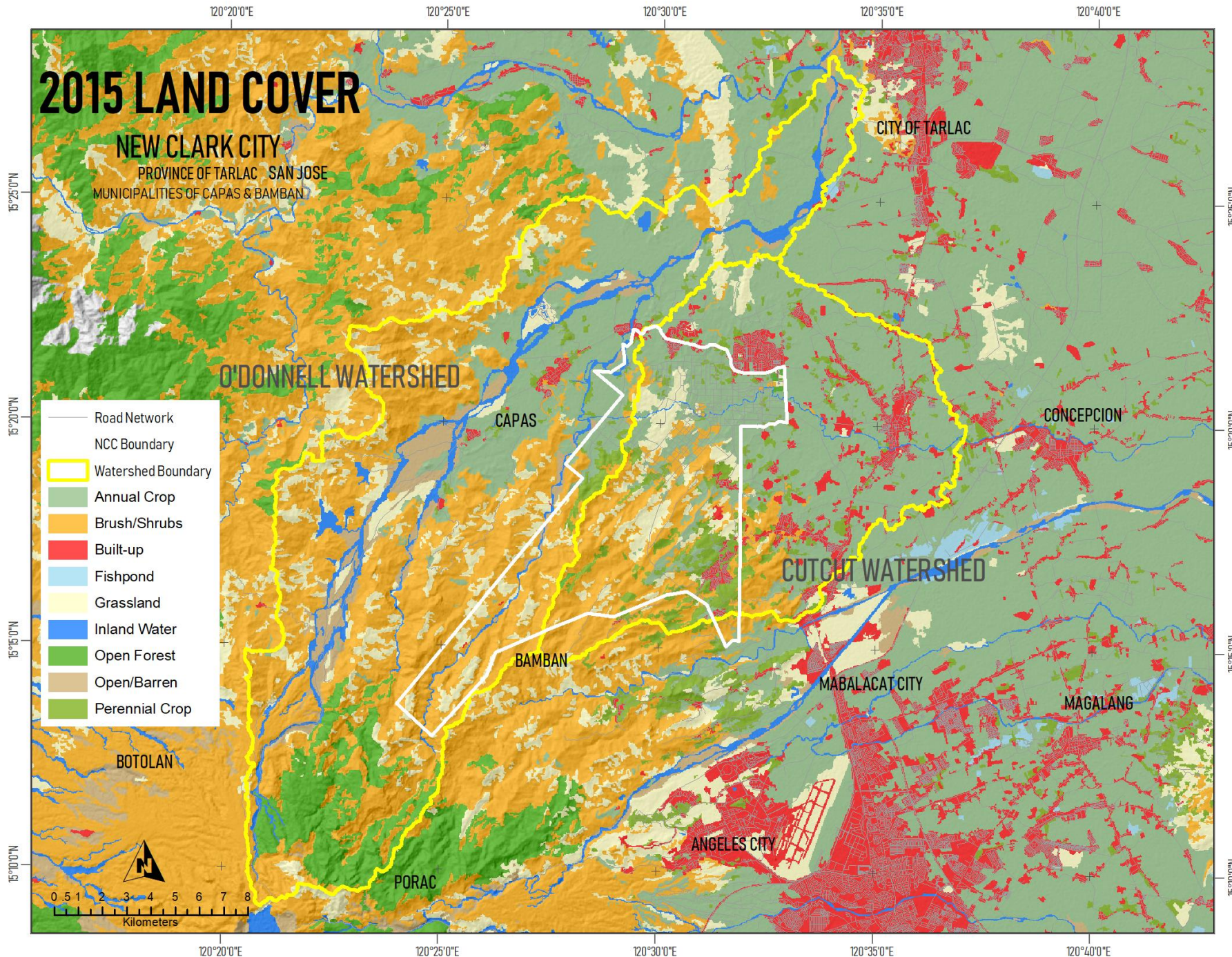
Change Prediction



# 2015 LAND COVER

## NEW CLARK CITY

PROVINCE OF TARLAC SAN JOSE  
MUNICIPALITIES OF CAPAS & BAMBAN

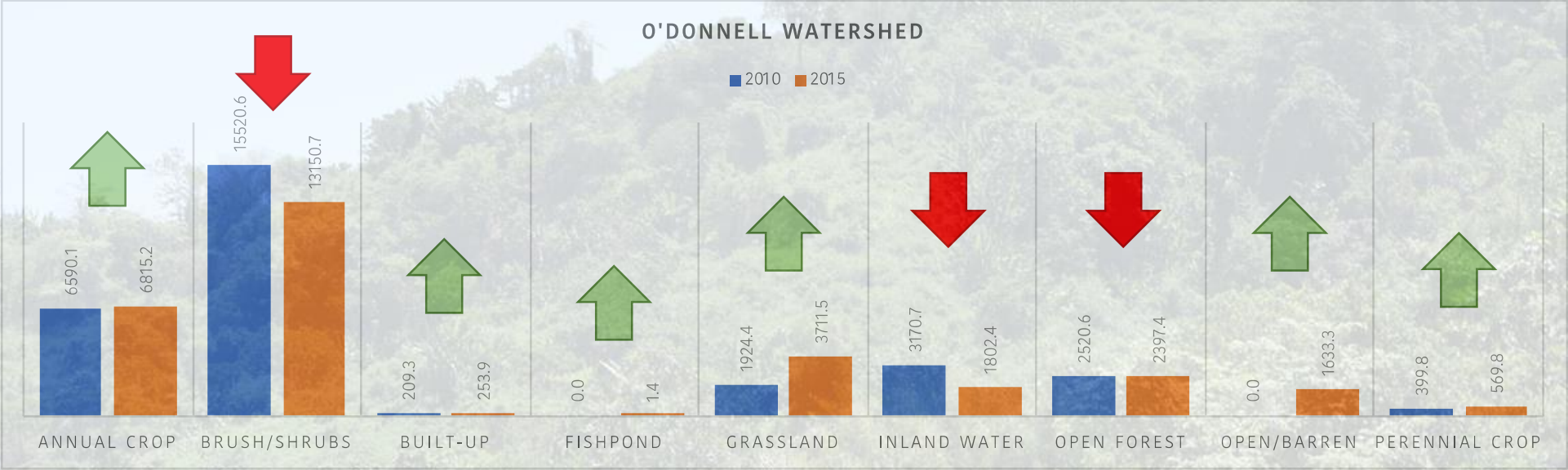


# RELATIVE CHANGE BETWEEN 2010 AND 2015

LAND COEVR	2010		2015		GAIN OR LOSS	
	AREA (Ha)	PERCENT (%)	AREA (Ha)	PERCENT (%)	AREA (Ha)	PERCENT (%)
Annual Crop	94,990	38.0	90,596	36.2	-4,394	-4.6
Brush/Shrubs	87,527	35.0	71,422	28.6	-16,105	-18.4
Built-up	18,720	7.5	21,629	8.7	2,909	15.5
Closed Forest	953	0.4	795	0.3	-158	-16.5
Fishpond	283	0.1	835	0.3	552	195.4
Grassland	11,188	4.5	25,022	10.0	13,833	123.6
Inland Water	7,512	3.0	5,866	2.3	-1,646	-21.9
Open Forest	19,850	7.9	21,414	8.6	1,564	7.9
Open/Barren	2,175	0.9	5,426	2.2	3,251	149.4
Perennial Crop	6,802	2.7	6,996	2.8	94	2.9
TOTAL	250,000	100.0	250,000	100		



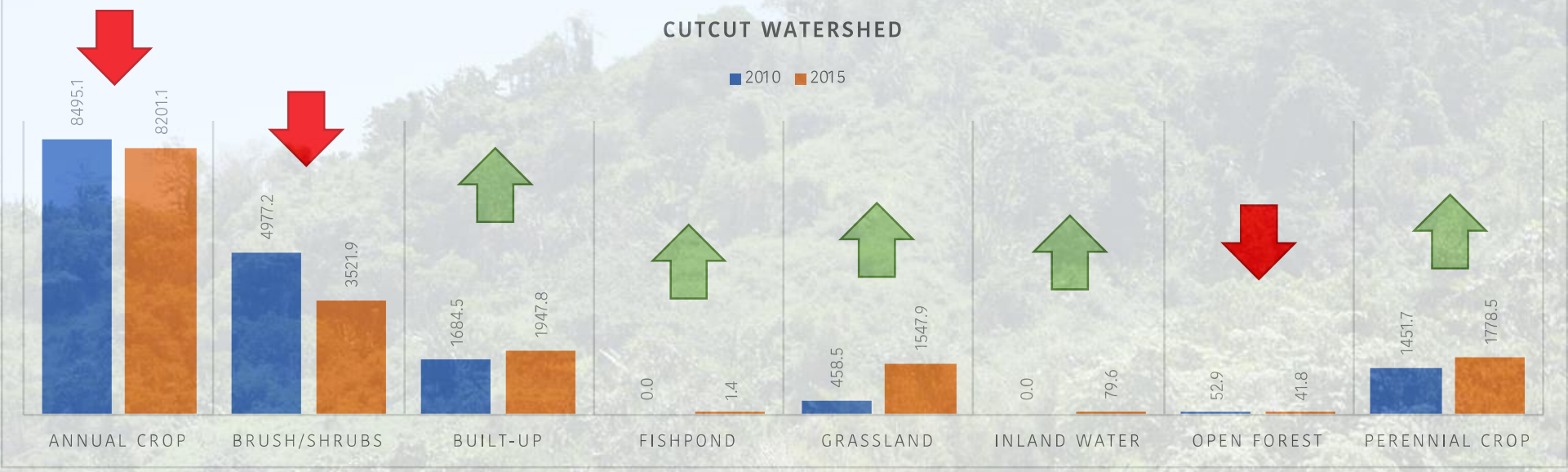
# O'DONNELL WATERSHED



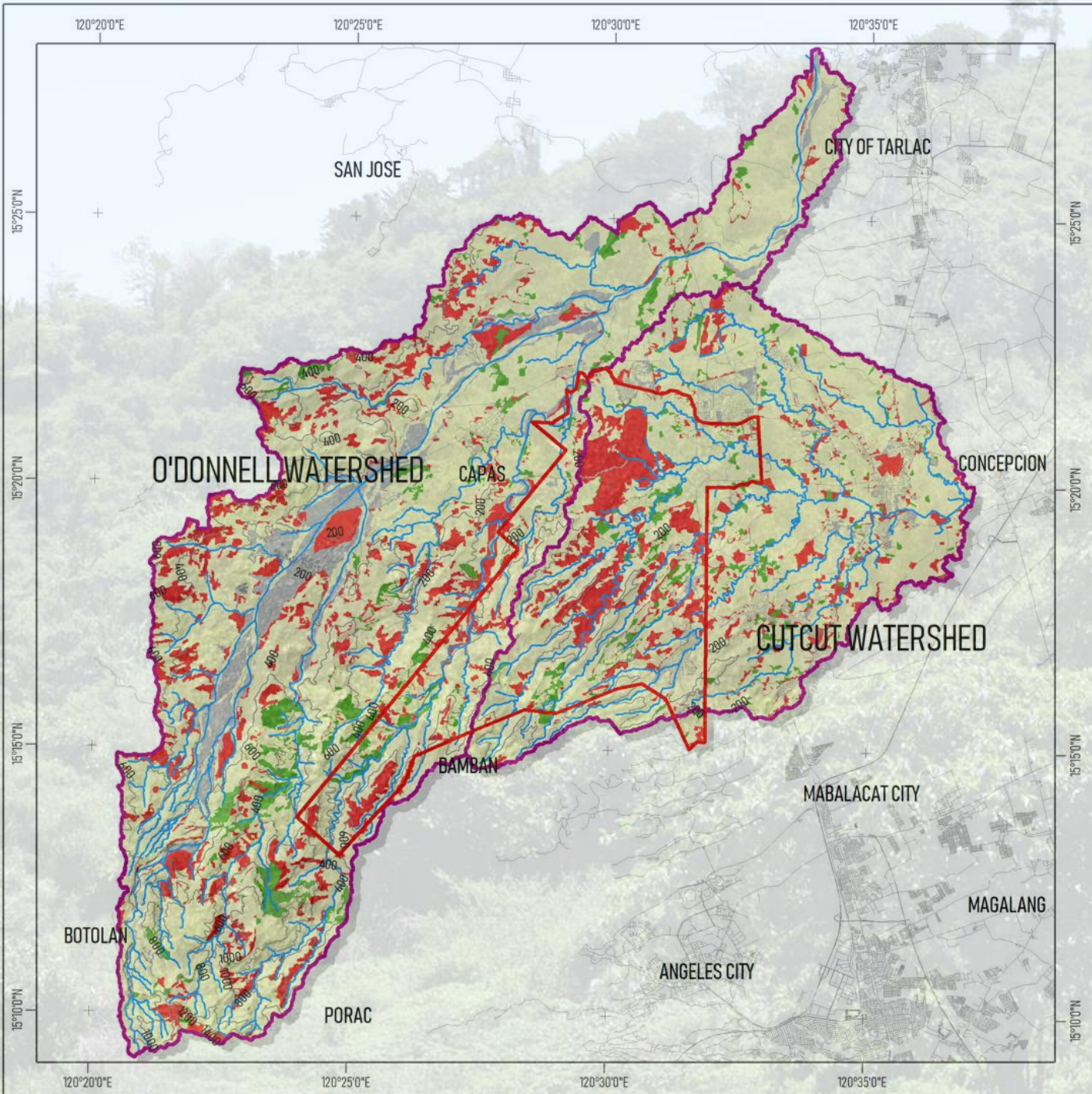
LAND COVER 2010	LAND COVER 2015									
	Annual Crop	Brush/Shrubs	Built-up	Fishpond	Grassland	Inland Water	Open Forest	Open/Barren	Perennial Crop	Grand Total
Annual Crop	5,754.93	128.97	56.83		128.13	205.16		98.24	217.87	6,590.13
Brush/Shrubs	543.75	11,710.86	3.59		2,324.02	250.30	429.59	192.99	65.55	15,520.63
Built-up	21.37	2.60	172.18	0.95	0.01	1.28		2.04	8.89	209.34
Grassland	190.60	643.70	7.86		849.08	91.95	0.48	139.14	1.58	1,924.38
Inland Water	259.41	69.41	4.38	0.46	389.92	1,231.13	12.68	1,199.57	3.73	3,170.69
Open Forest		525.18			18.47	21.62	1,954.61	0.71		2,520.60
Perennial Crop	45.10	70.00	9.03		1.90	1.00		0.63	272.19	399.85
Grand Total	6,815.16	13,150.72	253.86	1.41	3,711.54	1,802.43	2,397.35	1,633.33	569.80	30,335.61



# CUTCUT WATERSHED

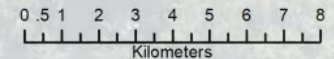


LAND COVER 2010	LAND COVER 2015								
	Annual Crop	Brush/Shrubs	Built-up	Fishpond	Grassland	Inland Water	Open Forest	Perennial Crop	Grand Total
Annual Crop	7,287.59	177.26	514.35		73.92	58.43	1.28	382.24	8,495.06
Brush/Shrubs	472.07	2,789.41	29.79		1,181.92	16.02	13.14	474.85	4,977.21
Built-up	223.90	40.95	1,287.40	1.35	28.19	2.53	1.59	98.57	1,684.48
Grassland	69.04	136.43	16.15		225.23		1.55	10.06	458.46
Open Forest	15.29	6.81	0.79		4.67	1.17	24.20		52.93
Perennial Crop	133.17	370.99	99.30		33.98	1.49		812.76	1,451.70
Grand Total	8,201.06	3,521.86	1,947.77	1.35	1,547.91	79.64	41.76	1,778.49	17,119.84



# TRENDS

**NEW CLARK CITY**  
 PROVINCE OF TARLAC  
 MUNICIPALITIES OF CAPAS & BAMBAN



WGS 1984 UTM Zone 50N

### LEGEND

- NCC Boundary
- Watershed Boundary
- Road Network
- Stream Network
- TREND**
- Negative
- Persistent
- Positive

### LOCATION MAP





# DRIVERS OF CHANGE OR EXPLANATORY VARIABLES

1. Elevation
2. Distance From Roads
3. Evidence Likelihood of Land Cover
4. Distance From Annual Crop
5. Distance From Rivers
6. Slope
7. Population
8. Distance From Built-up Areas

MODEL	ACCURACY (%)	SKILL MEASURE	INFLUENCE ORDER
With all variables	85.38	0.8406	N/A
Var. 1 constant	84.62	0.8322	7
Var. 2 constant	59.23	0.5552	3
Var. 3 constant	18.46	0.1105	1 (most influential)
Var. 4 constant	71.54	0.6895	4
Var. 5 constant	76.15	0.7399	5
Var. 6 constant	85.38	0.8406	8 (least influential)
Var. 7 constant	80.00	0.7818	6
Var. 8 constant	37.69	0.3203	2

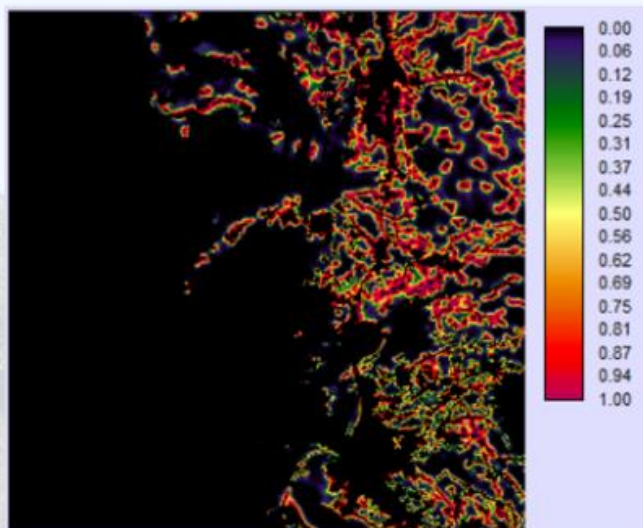




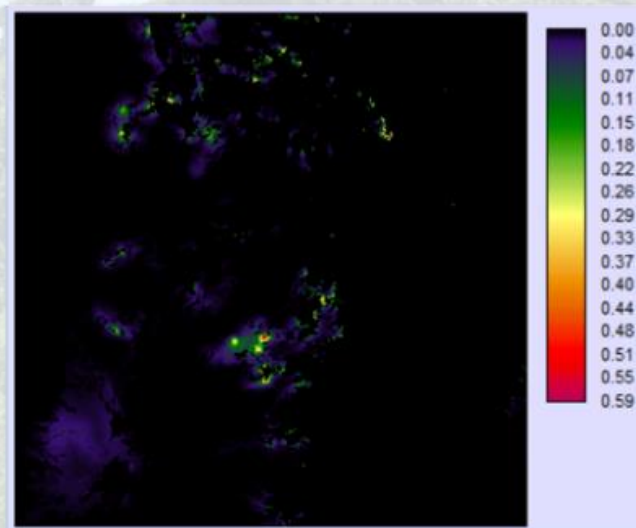
# TRANSITION POTENTIALS



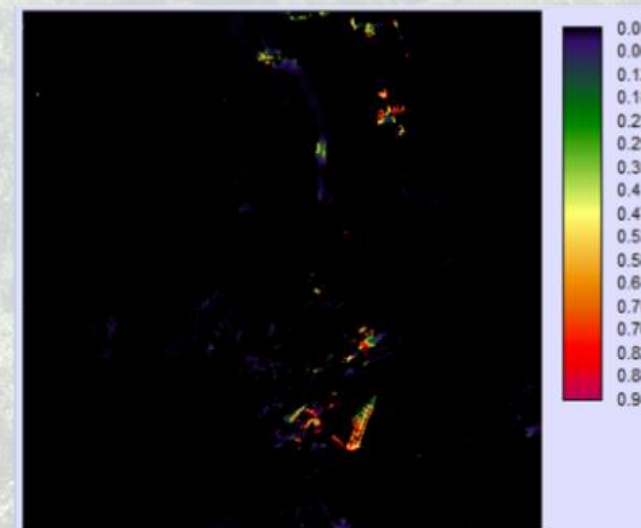
Annual to Built-up Areas



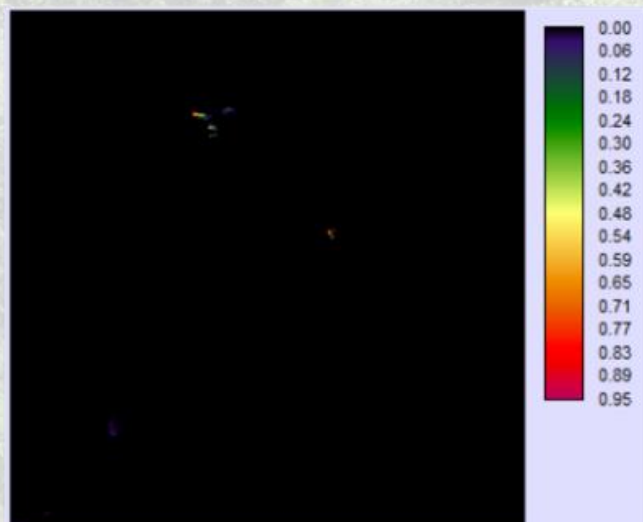
Brush/Shrubs to Built-up Areas



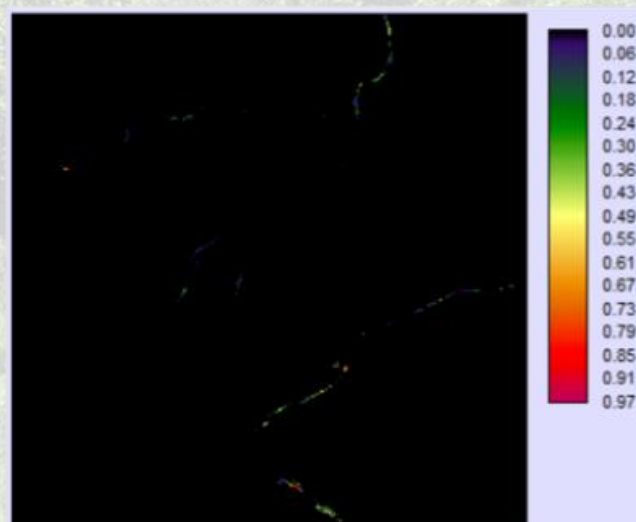
Grassland to Built-up Areas



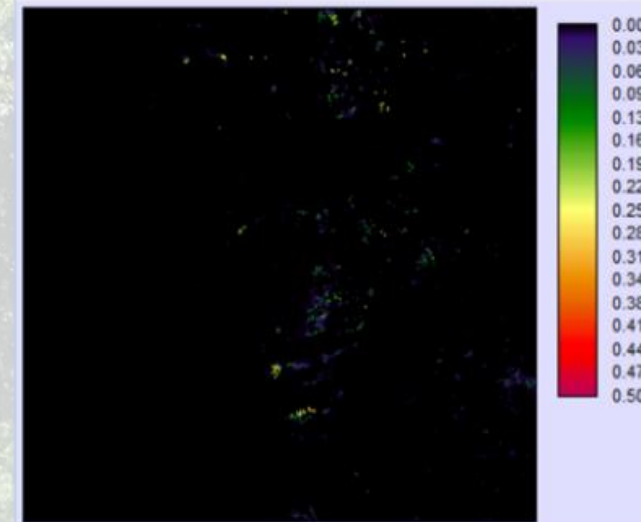
Open Forest to Built-up Areas



Open/Barren to Built-up Areas



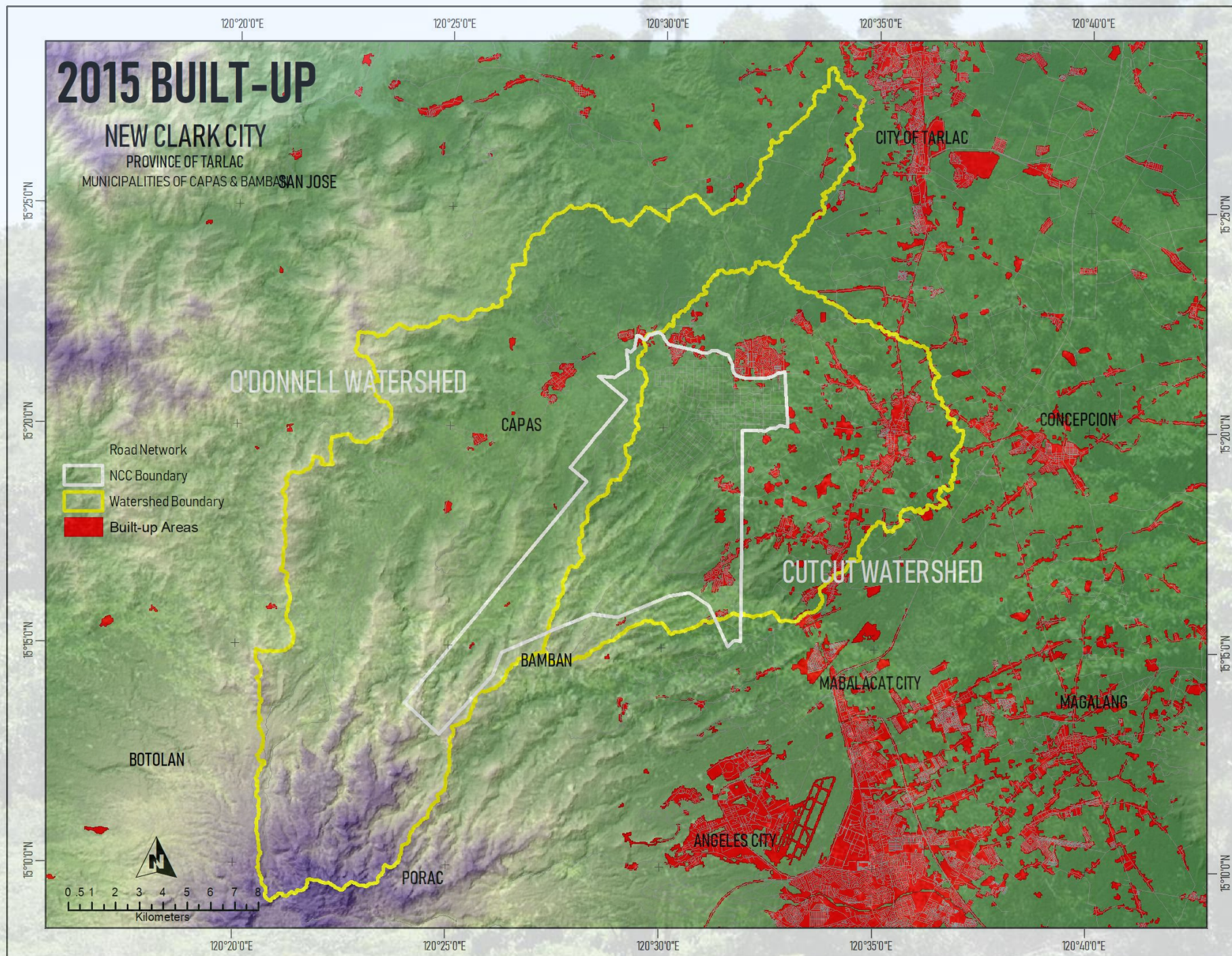
Perennial Crop to Built-up Areas





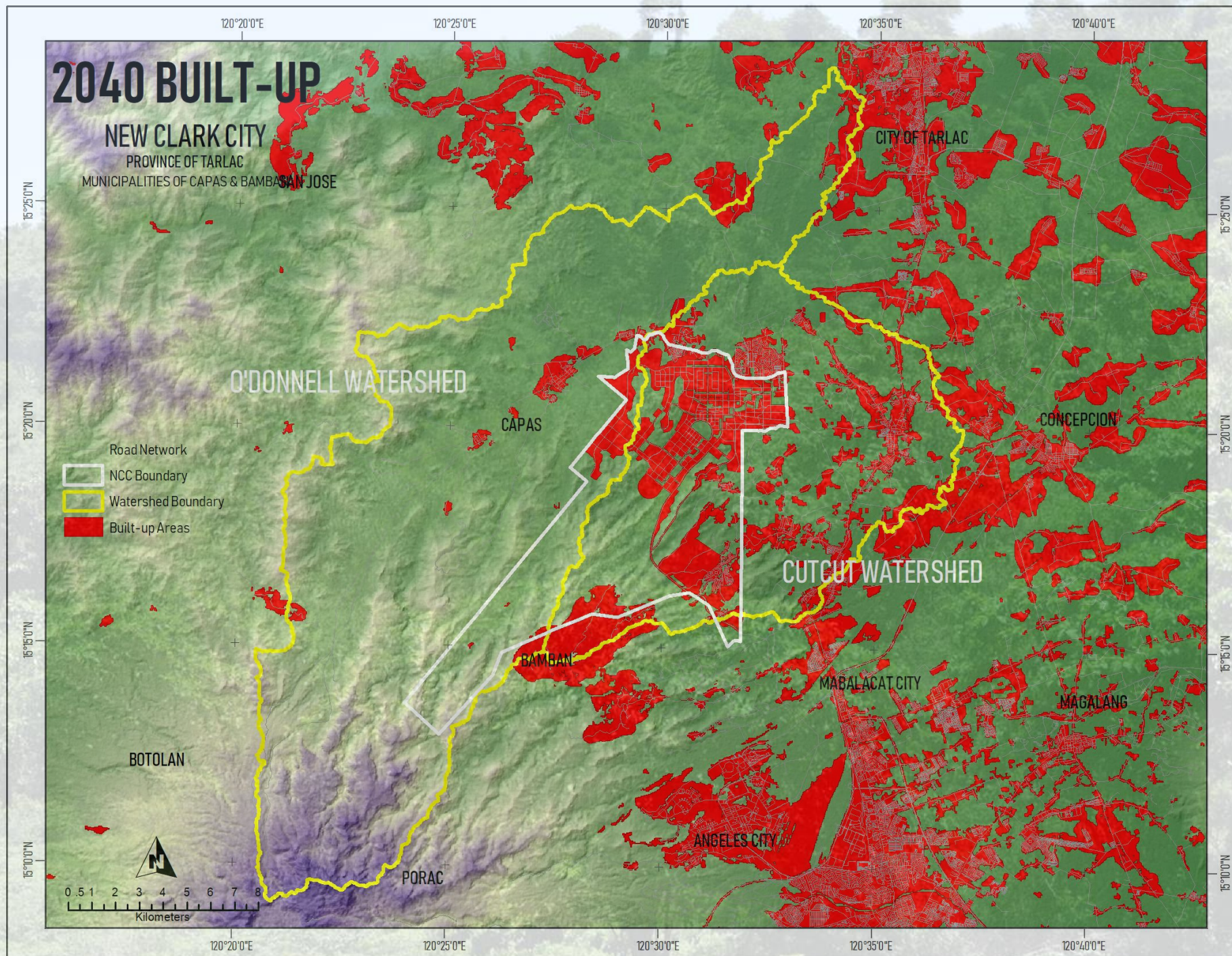
## CHANGE PREDICTION

- uses transition potentials to create predictions
- hard prediction yields a single realization based on a competitive land allocation



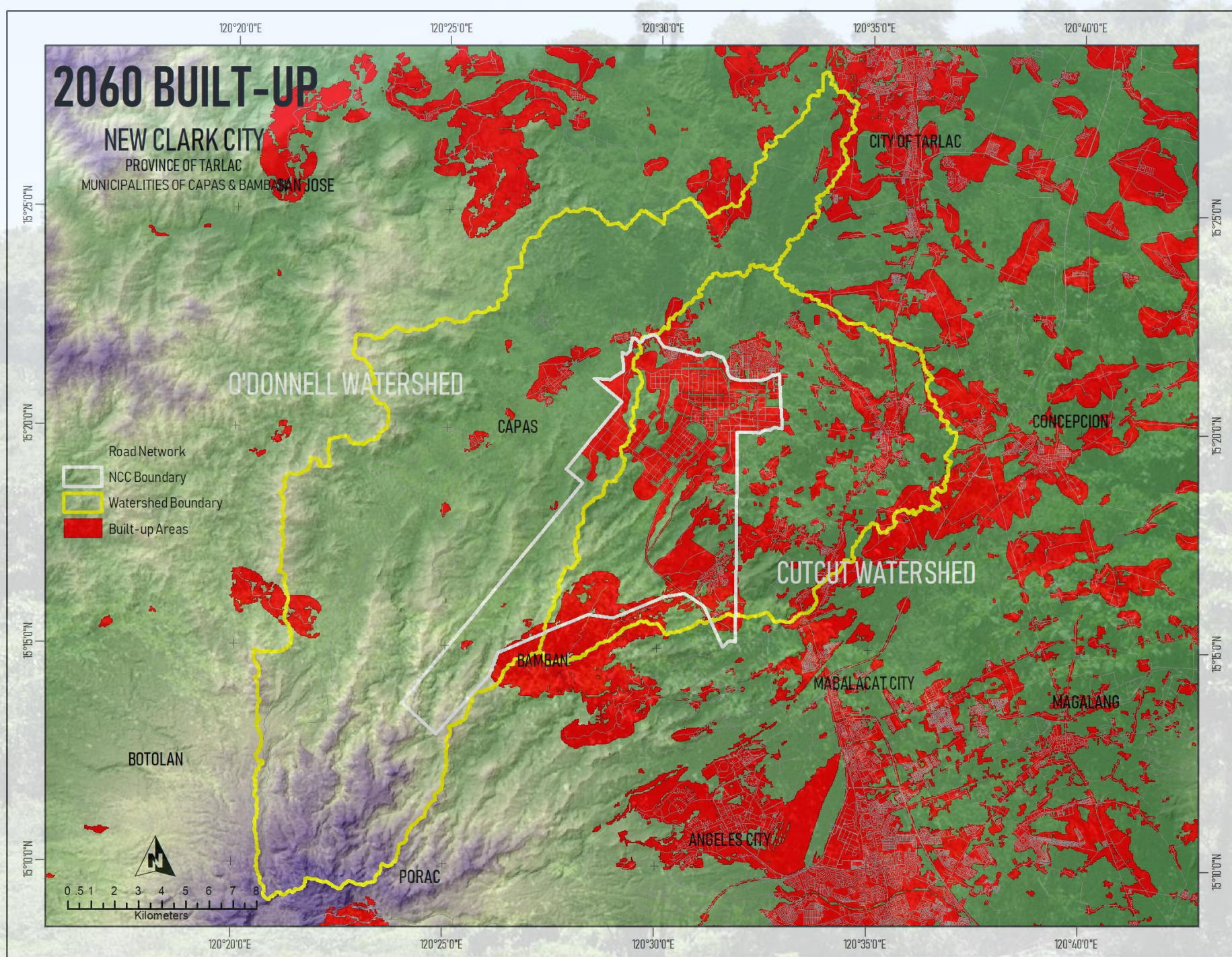


- increase in built-up in the northern portions of O'Donnell Watershed
- observed increase in built-up areas in the western and southern parts of Cutcut Watershed





Further expansion in the northern of O'Donnell and southern portions of Cutcut has been observed



# TREND IN URBAN AREAS

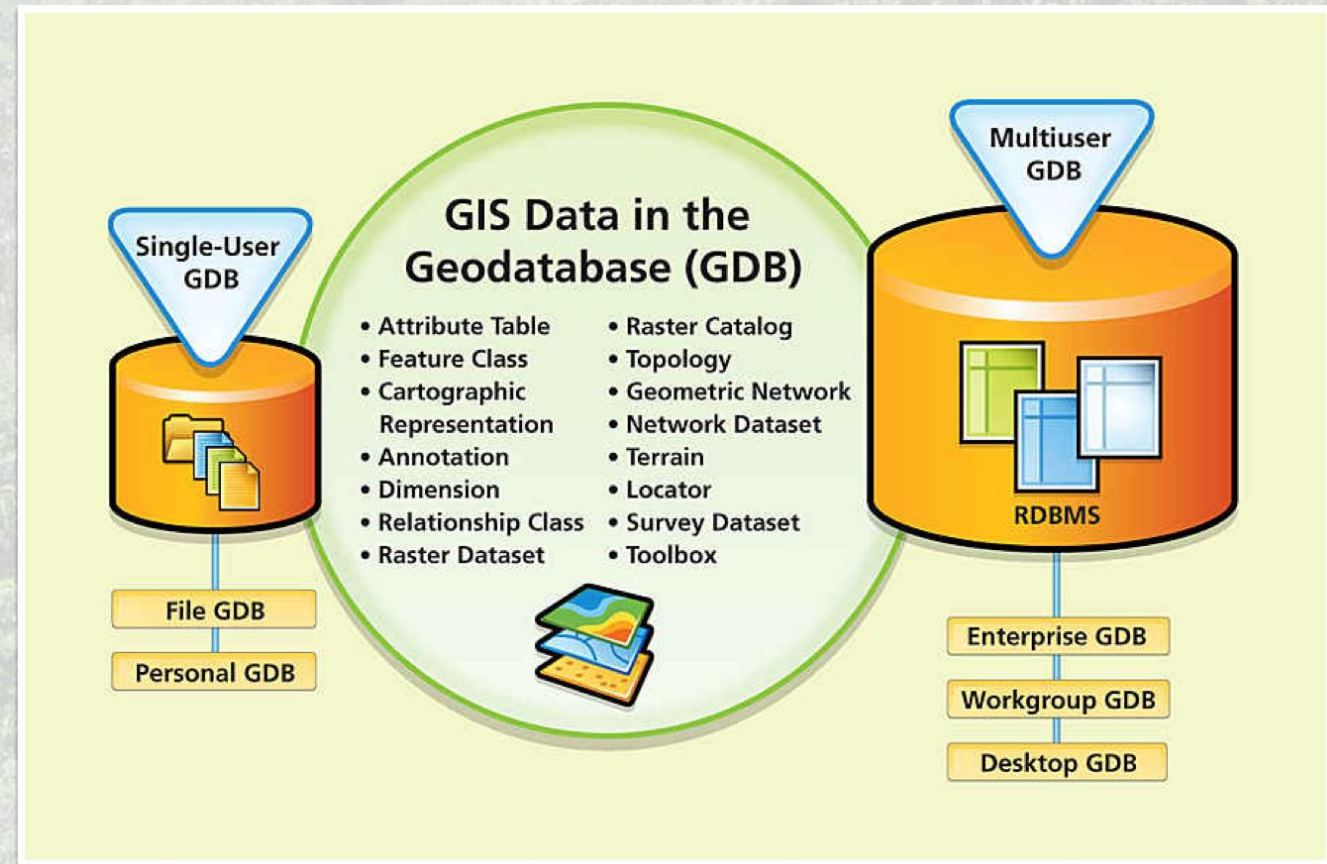
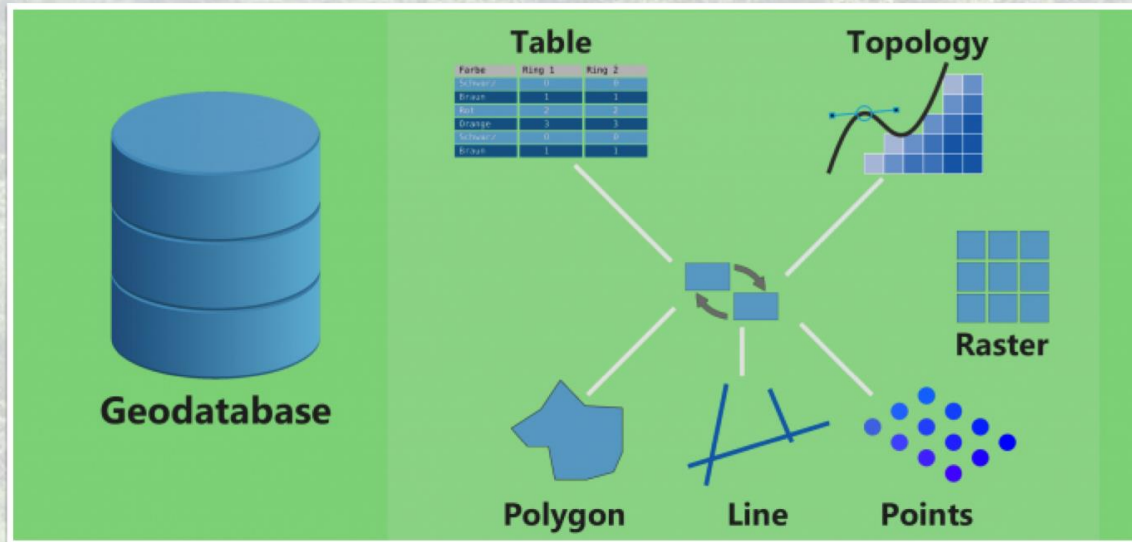


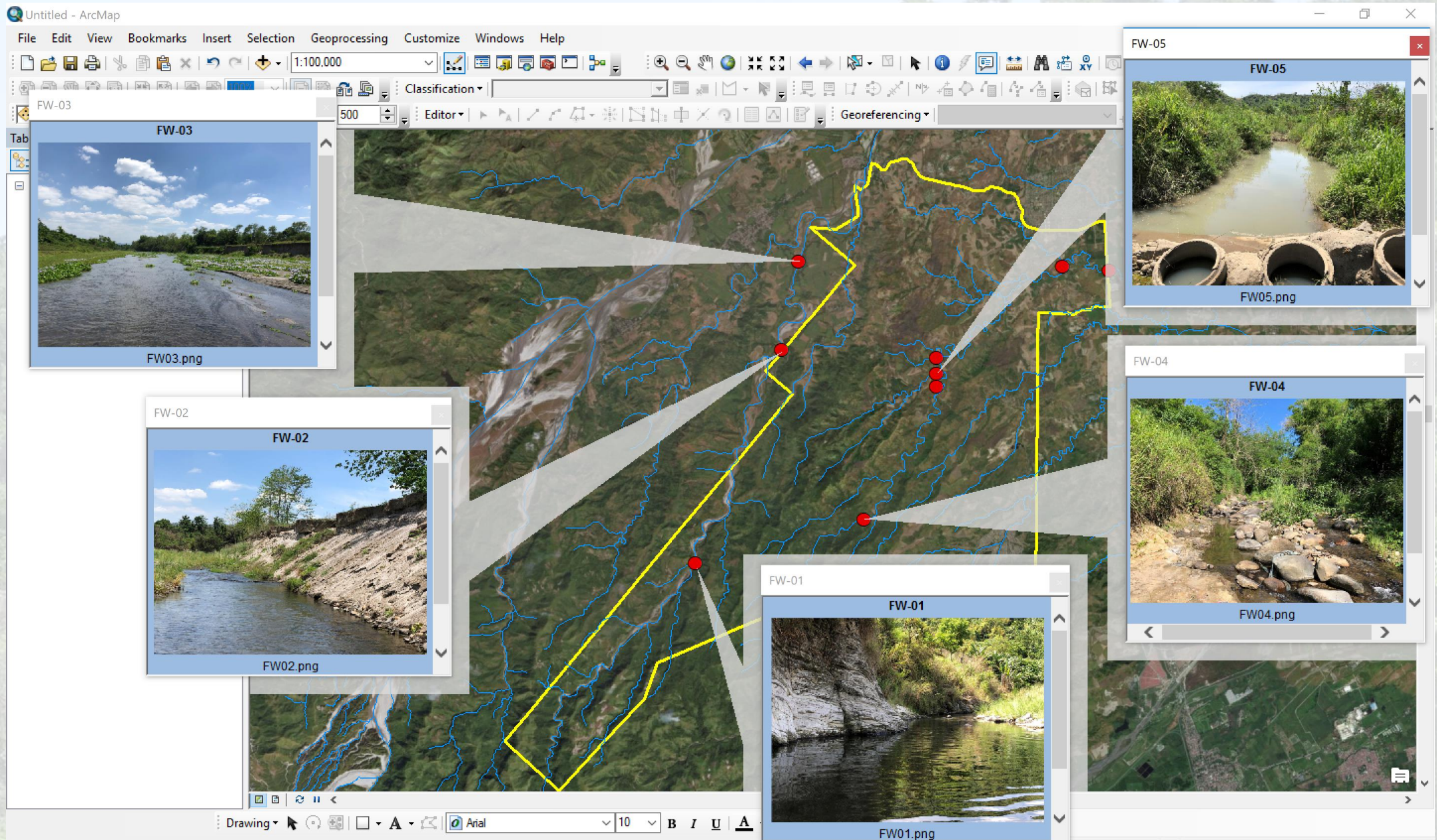
Trend in urban areas in NCC and in the two watersheds across different periods

# GEODATABASE

A **collection** of **geographic datasets** (tables, feature classes, and raster datasets) of various types held in a common file system folder

Database that is optimized to **store** and **query** data that represents objects defined in a geometric space





# GEODATABASE FOR FRESHWATER

Untitled - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:80,000

Classification


ncc\_fauna\_amphibia\_repti 500 Editor Georeferencing

Table Of Contents

Layers

- ncc\_fauna\_amphibia\_reptilia
- ncc\_2watersheds\_streams
- ncc\_boundary\_utm
- Basemap
- World Imagery

Transect 3




Rhinella marina.jpg

<a href="#">Rhinella marina.jpg</a>	<a href="#">Kaloula picta.jpg</a>
<a href="#">Polypedates leucomystax.jpg</a>	<a href="#">Gekko gecko.jpg</a>

SITE	3
SAMPLING	Transect 3
CODE	S3Mid
LONGITUDE	120.45503
LATITUDE	15.28501

Transect 1




Rhinella marina.jpg

<a href="#">Rhinella marina.jpg</a>	<a href="#">Polypedates leucomystax.jpg</a>
<a href="#">Occidozyga laevis.jpg</a>	<a href="#">Fejervarya cancrivora.jpg</a>
<a href="#">Hoplobatrachus rugulosus.jpg</a>	<a href="#">Gekko gecko.jpg</a>

SITE	1
SAMPLING	Transect 1
CODE	S1Mid
LONGITUDE	120.49807
LATITUDE	15.35135

Transect 2



Rhinella marina.jpg

<a href="#">Rhinella marina.jpg</a>	<a href="#">Polypedates leucomystax.jpg</a>
<a href="#">Fejervarya cancrivora.jpg</a>	<a href="#">Gekko gecko.jpg</a>
<a href="#">Bronchocela marmorata.jpg</a>	

Drawing

# GEODATABASE FOR FAUNA



Untitled - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize

1:80,000

Classificati

ncc\_fauna\_amphibia\_repti

500

Editor

Table Of Contents

Layers

- ncc\_fauna\_mammalia
- ncc\_fauna\_amphibia\_reptilia
- ncc\_2watersheds\_streams
- ncc\_boundary\_utm
- Basemap
- World Imagery

Transect 1

Transect 2

Transect 3

Transect 2 - Chrotomys mindorensis.jpg

Georeferencing

Cynopterus brachyotis.jpg

<a href="#">Cynopterus brachyotis.jpg</a>	<a href="#">Ptenochirus jaqori.jpg</a>
<a href="#">MacroGLOSSUS minimus.jpg</a>	<a href="#">Scotophilus kuhli.jpg</a>
<a href="#">Rattus tanezumi.jpg</a>	<a href="#">Rattus exulans.jpg</a>

Cynopterus brachyotis.jpg

<a href="#">Cynopterus brachyotis.jpg</a>	<a href="#">Ptenochirus jaqori.jpg</a>
<a href="#">MacroGLOSSUS minimus.jpg</a>	<a href="#">Eonycteris spelaea.jpg</a>
<a href="#">Scotophilus kuhli.jpg</a>	<a href="#">Rattus tanezumi.jpg</a>
<a href="#">Chrotomys mindorensis.jpg</a>	

Cynopterus brachyotis.jpg

<a href="#">Cynopterus brachyotis.jpg</a>	<a href="#">MacroGLOSSUS minimus.jpg</a>
<a href="#">Rattus tanezumi.jpg</a>	

Drawing

Arial

10

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GEODATABASE FOR FAUNA

Untitled - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:80,000

Classification

ncc\_fauna\_amphibia\_repti 500 Editor Georeferencing


Table Of Contents

Layers

- ncc\_fauna\_aves
- ncc\_fauna\_mammalia
- ncc\_fauna\_amphibia\_reptilia
- ncc\_2watersheds\_streams
- ncc\_boundary\_utm
- Basemap
- World Imagery

Transect 3

Transect 3

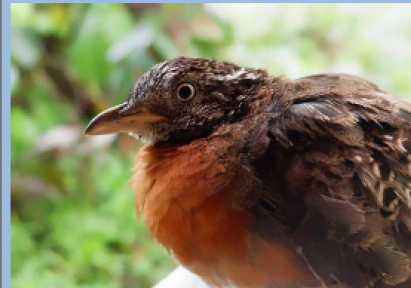


Nyticorax nycticorax.jpg

<a href="#">Nyticorax nycticorax.jpg</a>	<a href="#">Turnix ocellata.jpg</a>
<a href="#">Turnix suscitator.jpg</a>	<a href="#">Geopelia striata.jpg</a>
<a href="#">Chalcopaps indica.jpg</a>	<a href="#">Phapitreron leucotis.jpg</a>
<a href="#">Cuculus fugax.jpg</a>	<a href="#">Centropus viridis.jpg</a>
<a href="#">Halcyon chloris.jpg</a>	<a href="#">Halcyon smyrnensis.jpg</a>
<a href="#">Alcedo cyanopecta.jpg</a>	<a href="#">Pycnonotus goiavier.jpg</a>
<a href="#">Hypsipetes philippinus.jpg</a>	<a href="#">Convus macrorhynchos.jpg</a>
<a href="#">Megalurus palustris.jpg</a>	<a href="#">Gerygone sulphurea.jpg</a>
<a href="#">Cyornis ruficastra.jpg</a>	<a href="#">Lanius cristatus.jpg</a>
<a href="#">Lanius schach.jpg</a>	

Transect 2

Transect 2



Turnix ocellata.jpg

<a href="#">Turnix ocellata.jpg</a>	<a href="#">Geopelia striata.jpg</a>
<a href="#">Chalcopaps indica.jpg</a>	<a href="#">Phapitreron leucotis.jpg</a>
<a href="#">Cuculus fugax.jpg</a>	<a href="#">Centropus viridis.jpg</a>
<a href="#">Ninox philippensis.jpg</a>	<a href="#">Otus megalotis.jpg</a>
<a href="#">Halcyon chloris.jpg</a>	<a href="#">Halcyon smyrnensis.jpg</a>
<a href="#">Alcedo cyanopecta.jpg</a>	<a href="#">Pitta sordida.jpg</a>
<a href="#">Pycnonotus goiavier.jpg</a>	<a href="#">Hypsipetes philippinus.jpg</a>
<a href="#">Zoothera cinerea.jpg</a>	<a href="#">Rhipidura javanica.jpg</a>
<a href="#">Megalurus palustris.jpg</a>	<a href="#">Gerygone sulphurea.jpg</a>
<a href="#">Cyornis ruficastra.jpg</a>	<a href="#">Lanius cristatus.jpg</a>
<a href="#">Lanius schach.jpg</a>	

Drawing

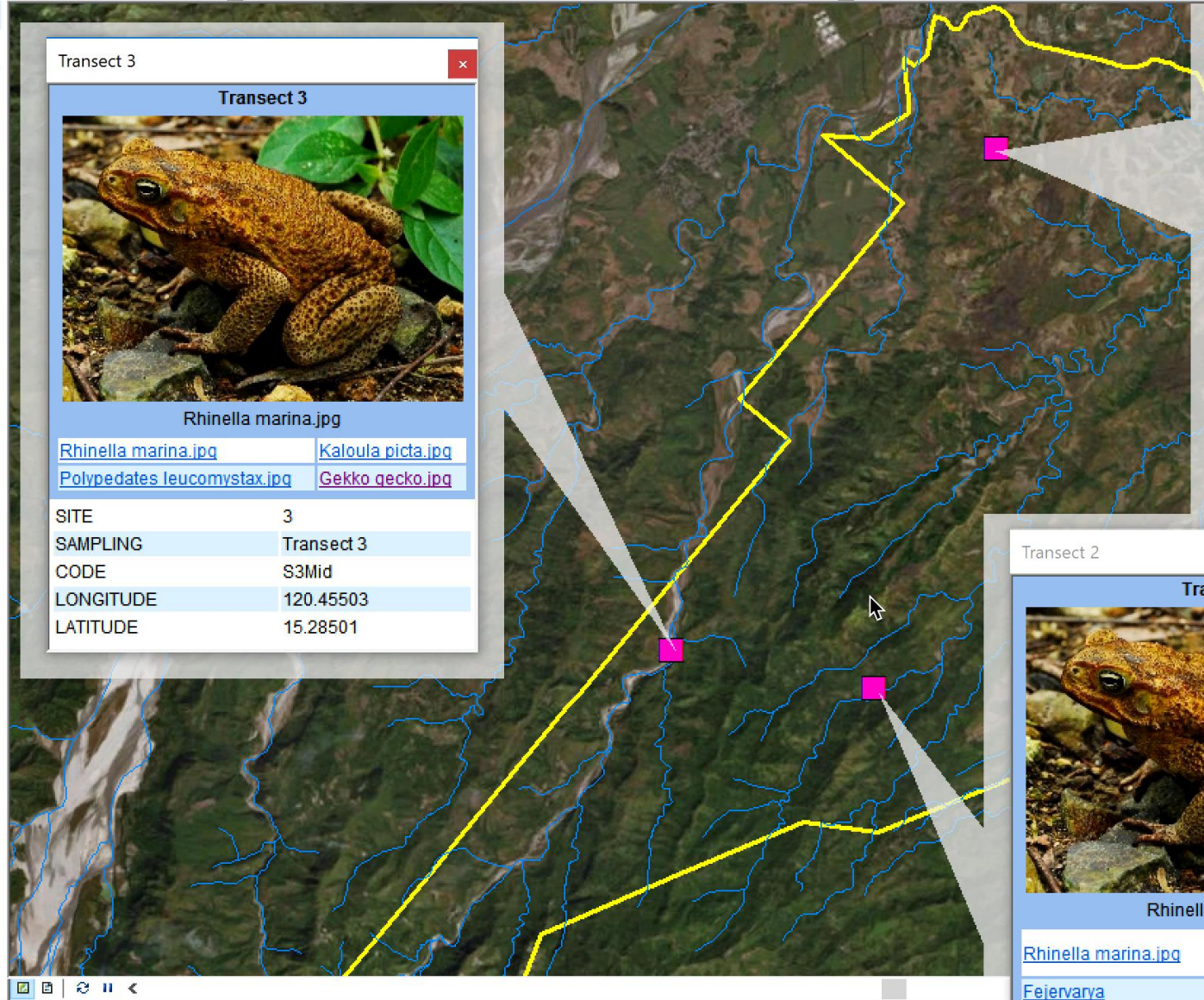
Arial 10 B I U

220518.02 1686920.143 Meters

# GEODATABASE FOR FAUNA


Table Of Contents

- Layers
  - ncc\_fauna\_amphibia\_reptilia
  - ncc\_2watersheds\_streams
  - ncc\_boundary\_utm
  - Basemap
  - World Imagery



Transect 3

**Transect 3**




Rhinella marina.jpg

<a href="#">Rhinella marina.jpg</a>	<a href="#">Kaloula picta.jpg</a>
<a href="#">Polypedates leucomystax.jpg</a>	<a href="#">Gekko gecko.jpg</a>

SITE	3
SAMPLING	Transect 3
CODE	S3Mid
LONGITUDE	120.45503
LATITUDE	15.28501

Transect 1

**Transect 1**



Rhinella marina.jpg

<a href="#">Rhinella marina.jpg</a>	<a href="#">Polypedates leucomystax.jpg</a>
<a href="#">Occidozyga laevis.jpg</a>	<a href="#">Fejervarya cancrivora.jpg</a>
<a href="#">Hoplobatrachus rugulosus.jpg</a>	<a href="#">Gekko gecko.jpg</a>

SITE	1
SAMPLING	Transect 1
CODE	S1Mid
LONGITUDE	120.49807
LATITUDE	15.35135

Transect 2

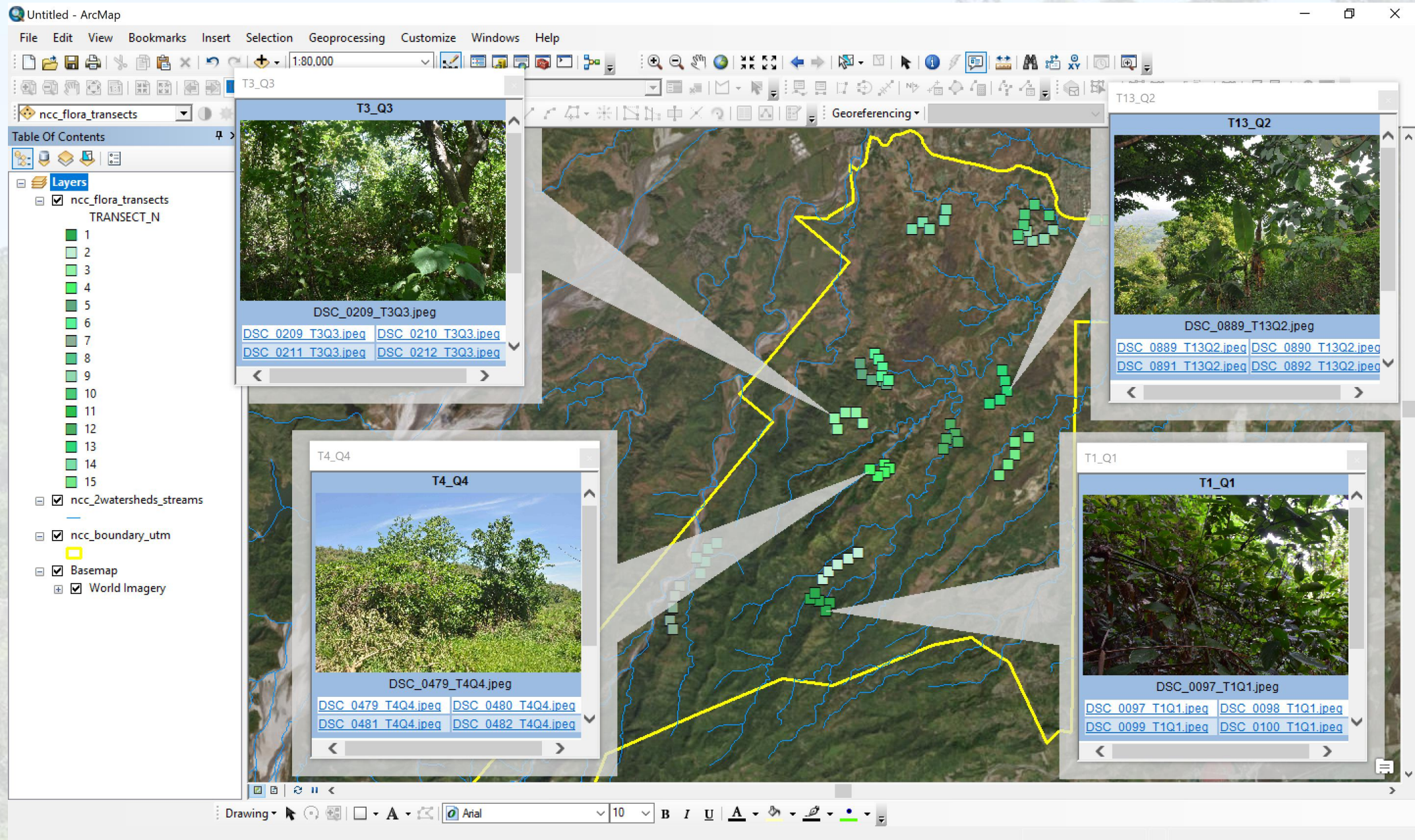
**Transect 2**



Rhinella marina.jpg

<a href="#">Rhinella marina.jpg</a>	<a href="#">Polypedates leucomystax.jpg</a>
<a href="#">Fejervarya cancrivora.jpg</a>	<a href="#">Gekko gecko.jpg</a>
<a href="#">Bronchocela marmorata.jpg</a>	





**GEODATABASE FOR FLORA**

NCC Geodatabase.mxd - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:80,000

Classification

ncc\_flora\_transects\_iba

500

Editor

Georeferencing

Table Of Contents

Layers

- ncc\_flora\_transects
  - TRANSECT\_N
    - 1
    - 2
    - 3
    - 4
    - 5
    - 6
    - 7
    - 8
    - 9
    - 10
    - 11
    - 12
    - 13
    - 14
    - 15
- ncc\_flora\_transects\_iba
- ncc\_fauna\_aves
- ncc\_fauna\_mammalia
- ncc\_fauna\_amphibia\_reptilia
- ncc\_2watersheds\_streams
- ncc\_boundary\_utm
- Basemap
- World Imagery

Identify

Identify from: <Top-most layer>

- Mangga
- Hagonoi
- Alahan
- Narra**
- Dayang
- Wild sunflower
- Talahib
- Dilang butiki

Location:

Field	Value
OBJECTID	839
TRANSECT	2
QUADRAT	0
TRANS_QUAD	T2_Q0
PLOT	OPP
COMMON_NAME	Narra
GENUS	Pterocarpus
SPECIES	indicus
AUTHOR	Willd.
SCIENTIFIC_NAME	Pterocarpus indicus Willd.
FAMILY	Fabaceae
PERCENT_COVER	<null>
DBH_cm_	<null>
TH_m_	<null>
COUNT	<null>
DAO_2017_11	VU
IUCN	EN
ENDEMISM	NE
NPR	<null>
DISTRIBUTION	Throughout the Philippines

Identified 1 feature

Drawing

Arial

10

B I U

244415.234 1696000.662 Meters

# GEODATABASE FOR FLORA

NCC Geodatabase.mxd - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:80,000

Classification

ncc\_flora\_transects\_iba

500

Editor

Georeferencing

Table Of Contents

Layers

- ncc\_flora\_transects
  - TRANSECT\_N
    - 1
    - 2
    - 3
    - 4
    - 5
    - 6
    - 7
    - 8
    - 9
    - 10
    - 11
    - 12
    - 13
    - 14
    - 15
- ncc\_flora\_transects\_iba
- ncc\_fauna\_aves
- ncc\_fauna\_mammalia
- ncc\_fauna\_amphibia\_reptilia
- ncc\_2watersheds\_streams
- ncc\_boundary\_utm
- Basemap
  - World Imagery

Identify

Identify from: <Top-most layer>

- Antipolo
- Mali-mali
- Garcinia mcgregorii
- Sablot
- Is-is
- Kalios
- Kuronitas
- Salingkugi

Location:

Field	Value
OBJECTID	126
TRANSECT	4
QUADRAT	2
TRANS_QUAD	T4_Q2
PLOT	20x20
COMMON_NAME	Antipolo
GENUS	Artocarpus
SPECIES	blancoi
AUTHOR	(Elmer) Merr.
SCIENTIFIC_NAME	Artocarpus blancoi (Elmer) Merr.
FAMILY	Moraceae
PERCENT_COVER	<null>
DBH_cm_	20
TH_m_	9
COUNT	<null>
DAO_2017_11	OWS
IUCN	VU
ENDEMISM	PE
NPR	<null>
DISTRIBUTION	BATAN, LUZON, MINDORO, PALAWAN, NEGR

Identified 1 feature

Drawing

Arial 10 B I U

244351.734 1691682.653 Meters

# GEODATABASE FOR FLORA

1:80,000

Classification

ncc\_flora\_transects\_iba

500

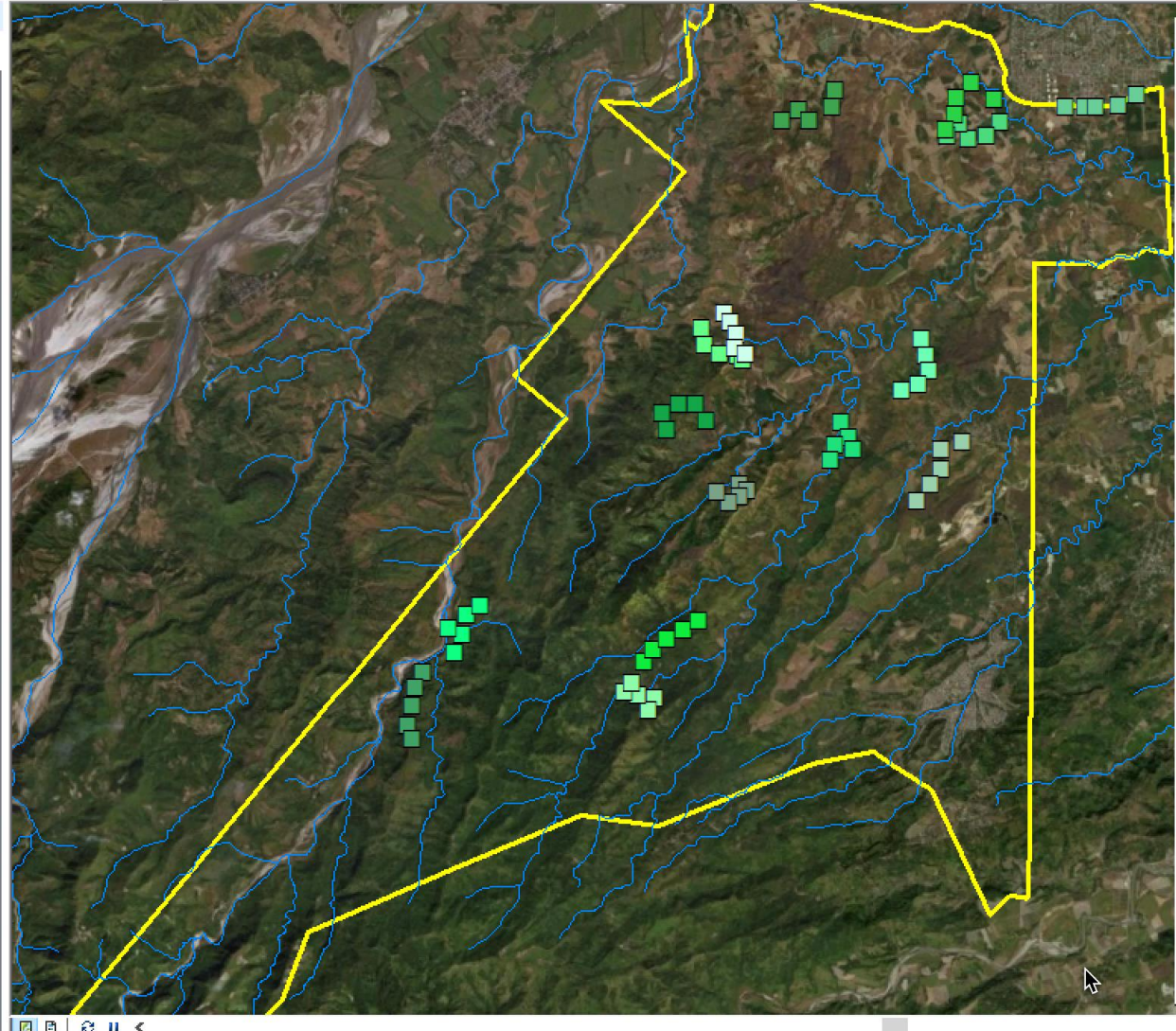
Editor

Georeferencing

Table Of Contents

**Layers**

- ncc\_flora\_transects
  - TRANSECT\_N
    - 1
    - 2
    - 3
    - 4
    - 5
    - 6
    - 7
    - 8
    - 9
    - 10
    - 11
    - 12
    - 13
    - 14
    - 15
- ncc\_flora\_transects\_iba
- ncc\_fauna\_aves
- ncc\_fauna\_mammalia
- ncc\_fauna\_amphibia\_reptilia
- ncc\_2watersheds\_streams
- ncc\_boundary\_utm
- Basemap
  - World Imagery



**Identify**

Identify from: <Top-most layer>

- ncc\_flora\_transects
  - T13\_Q0
    - ncc\_flora\_data
      - Pakiling
      - Sablol
      - Kakauate
      - Is-is
      - Duhat
      - ..

Location: 233,352.232 1,695,604.074 Meters

Attachments (4)

Field	Value
OBJECTID	61
Shape	Point
TRANSECT_N	13
QUADRAT	0
TRANS_QUAD	T13_Q0
LONGITUDE	120.516631
LATITUDE	15.323222
BIO_VALUE	9

Identified 1 feature

Drawing

Arial

10

B I U

## Loss of Natural Capital & Pressures in the watershed

- Declining vegetation cover
- Habitat loss and degradation
- Decrease of wildlife population
- Encroachment of invasive species
- Decreasing areas and quality of inland water

## Impact of urban development

- Projected high conversion to built-up areas in particular north to northeast of southwest NCC (upper Cutcut) and upper portion of O'Donnell Watershed
- Increase in population and projected high conversion to built-up areas in particular north to northeast and southwest of NCC (upper Cutcut); and upper portion of O'Donnell Watershed

Project-level

Inter-LGU

Watershed

## Nature-based Solutions



### Environment

- Restoration
- Protection
- Promotion of BD



### People & Community

- Inclusion & Partnership models



### Governance

- Policy & Plans
- Mitigation measures
- Synergy



# Recommended Measures & Nature-based Solutions



## Environment

- Establish important biodiversity & conservation areas
- Promote use of indigenous, native & endemic species
- Biodiversity-friendly technology in monitoring, protection and remediation
- Wet season biodiversity study



## People & Community

- Engage community as supplier (or contract growers) of native & endemic species, even instant trees
- Establish Payment for Ecosystem Services (PES) scheme



## Governance

- Integrate recommended mitigation measures to NCC design & operation guidelines
- Synergy of NCC with LGU mandated plans & dev't programs
- Multi-sector collaboration to safeguard & effectively manage watersheds
- Policy to adopt DENR-BMB Tech Bulletin 2018-02 on urban biodiversity
- Create NCC Sustainability Management Unit
- Develop Biodiversity Management Program

**THANK YOU FOR  
LISTENING!**