Complex Dynamical Systems

A Series of Ten Lectures to the Ross Institute, 2011-2012

by

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Series Outline

1. Nov 2, Intro: Epiphany, What, Why, How

2. Nov 9, Grs. K, 1: Dynamical Systems (DS)

3. Nov 16, Grs 2, 3, 4: Complex Dyn Sys (CDS)

4. Nov 21, Grs 5, 6, 7, 8: NetLogo CDS Models

5. Dec 7, Grs 9, 10, 11: NetLogo CDS Models

Lec. 1: Introduction

- A. My epiphany of the miracle year, 1972.
- B. WHAT: Systems thinking, General systems theory, cybernetics, system dynamics, and complex dynamical systems (CDS).
- C. WHY: The Spiral and World Cultural History as systems, systems thinking to understand the future.
- D. HOW: Foregrounding the systems of each grade with NetLogo (needs participation).

Lec. 2: Dynamical Sys.

- A. Stairway 2 Chaos
- B. Attractors, Basins, and Separatrices
- C. Schemes and Bifurcations
- D. Animated Examples

Lec. 3: Complex DS

- Grade K: Logistic, Period doubling bifurcation
- Grade 1: Van der Pol, Hopf bifurcation
- Grade 2: Daisyworld (CDS)
- Grade 3: Wolves and sheep
- Grade 4: Rabbits, grass, and weeds

Lec. 4: Middle School

- Grade 5: Riverine Civilizations, 3500-1450 BCE
  Ecosystem, Markets, Warfare

- Grade 6: Cultural Transformation, 1450-350 BCE
  Trade of ideas, paper, plunder

- Grade 7: Religions, Empires, 350 BCE -800 CE
  Silk Road, Lingua Franca, Currency

- Grade 8: Medieval Climax, 800-1453 CE
  Judeo-Christian-Islamic transmissions, Mecca

Fibers/Themes

- Threads (eg, systems thread) consist of fibers or themes (eg, ecosystem, trade route)

- Lower school exemplary systems (daisyworld, wolves-sheep, rabbits-grass-weeds) are all in the ecosystem theme

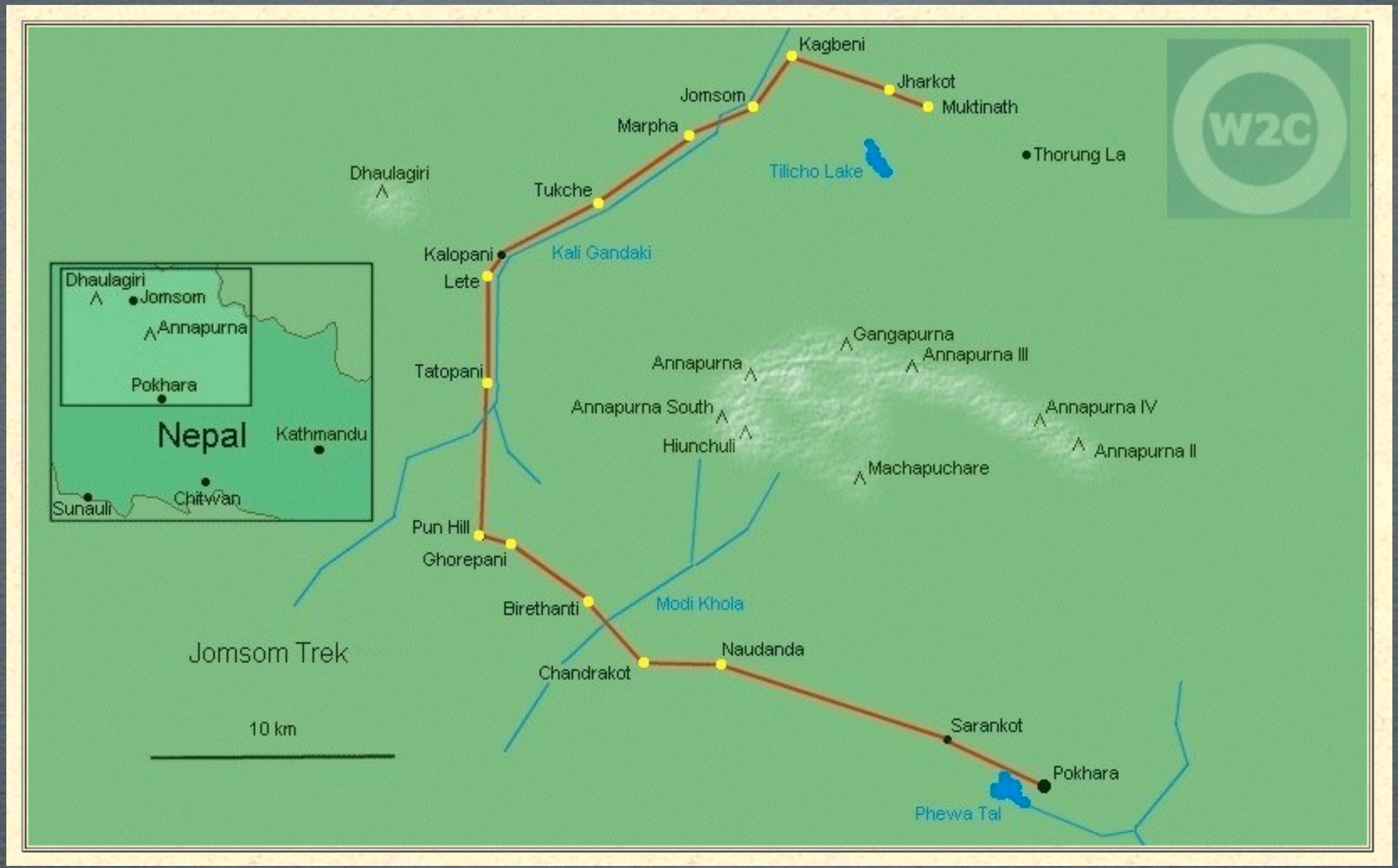
- Middle school exemplary systems will be in the trade route theme

Trade Routes

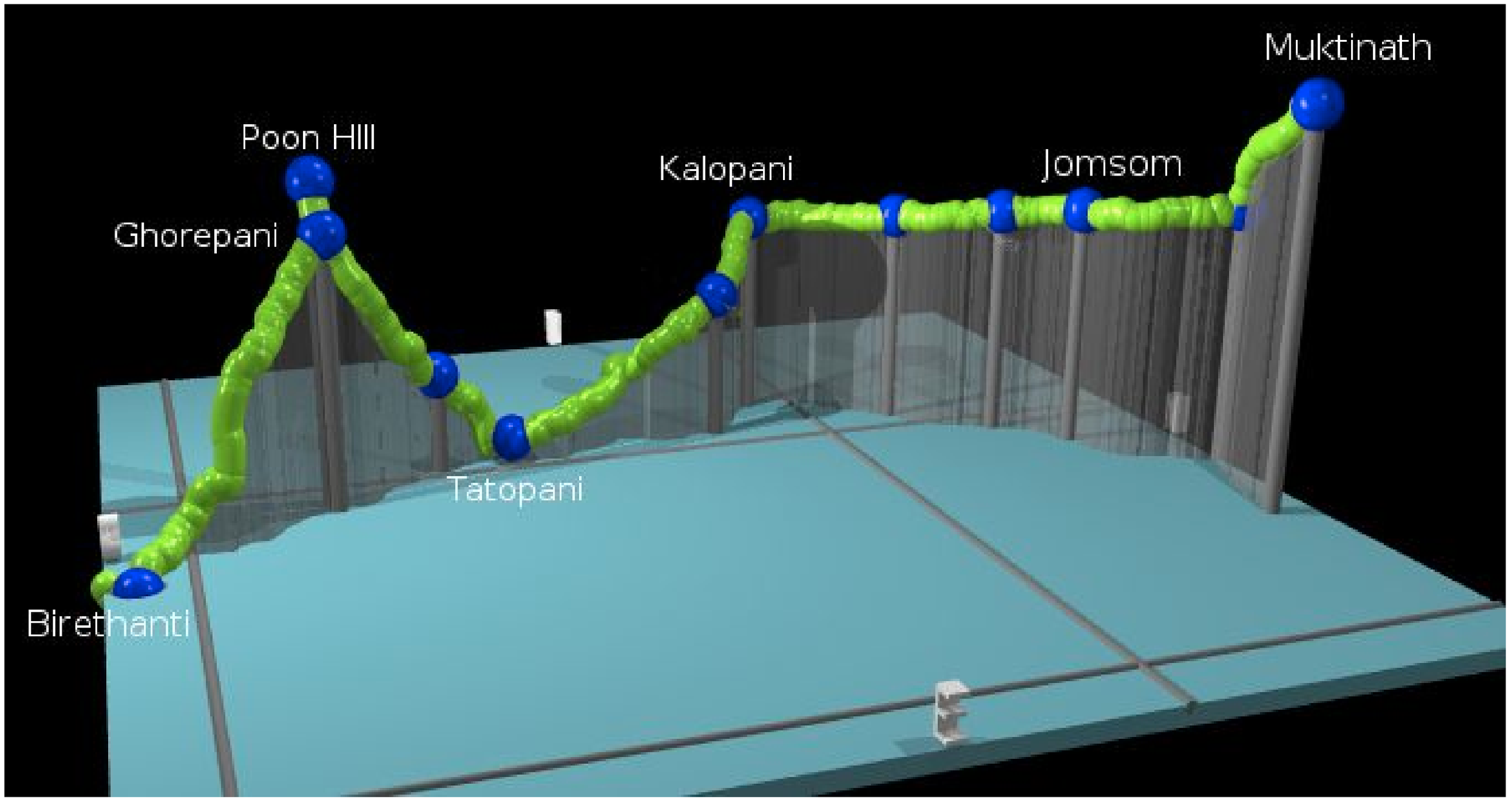
Pokhara-Jomsom Route

My Trek, 1972

- Pokhara (Nepal) -- Jomsom (Border Tibet)
- Pack Trains (Dzos, Yaks)
- Distance: 60 miles (each way)
- Primary trade: Rice / Salt
- Central station: Tatopani (Nepal)


Kagbeni
Jharkot
Jomsom
Muktinath
Marpha
Thorung La
Tilicho Lake
Dhaulagiri
Tukche
Kalopani
Kali Gandaki
Lete
Dhaulagiri
Jomsom
Annapurna
Pokhara
Nepal
Kathmandu
Chitwan
Sunauli
Tatopani
Gangapurna
Annapurna III
Annapurna
Annapurna South
Annapurna IV
Hiunchuli
Annapurna II
Machapuchare
Pun Hill
Ghorepani
Birethanti
Modi Khola
Naudanda
Chandrakot
Sarankot
Pokhara
Phewa Tal
Jomsom Trek
10 km

Trail Map



Elevation Detail

Elevations, Feet

- Pokhara, 2900 (+6600)
- Ghorapani, 9500 (-5500)
- Tatopani, 4000 (+4200)
- Kalopani, 8200 (+800)
- Jomson, 9000

The Agents

Yaks, Dzos, Humans

Nepali Yaks and Drovers to Pickup

Dzo, loaded for Mount Everest

Yaks vs Dzos

- Yaks are most efficient, subsisting on 6 lbs of wild hay per day up to 20,000 feet, domestic females weigh about 500 lbs.

- Dzos are hybrids of yaks and domestic cows, are larger and stronger than yaks, and are commonly used on lower elevations.

Pack Train Economics

Haggling the Exchange Rate

Rice Cost of 8 days Transportation

- Food for 40 animals (wild hay): 500 lbs
- Food and salary for 10 drovers: 160 lbs
- Taxes, tolls, and payoffs: 140 lbs
- Total per load of 200 lbs per animal: 20 lbs

Environmental Cost

- Cost to environment feedstock per animal
- Number of animals grazing per year
- Carrying capacity of trail
- Valuation of trail ecosystem
- Effect on exchange rate

Complex Dynamical System

- Yaks and wild grasses oscillate
- Stocks of rice and salt follow yaks
- Exchange rate follows stocks

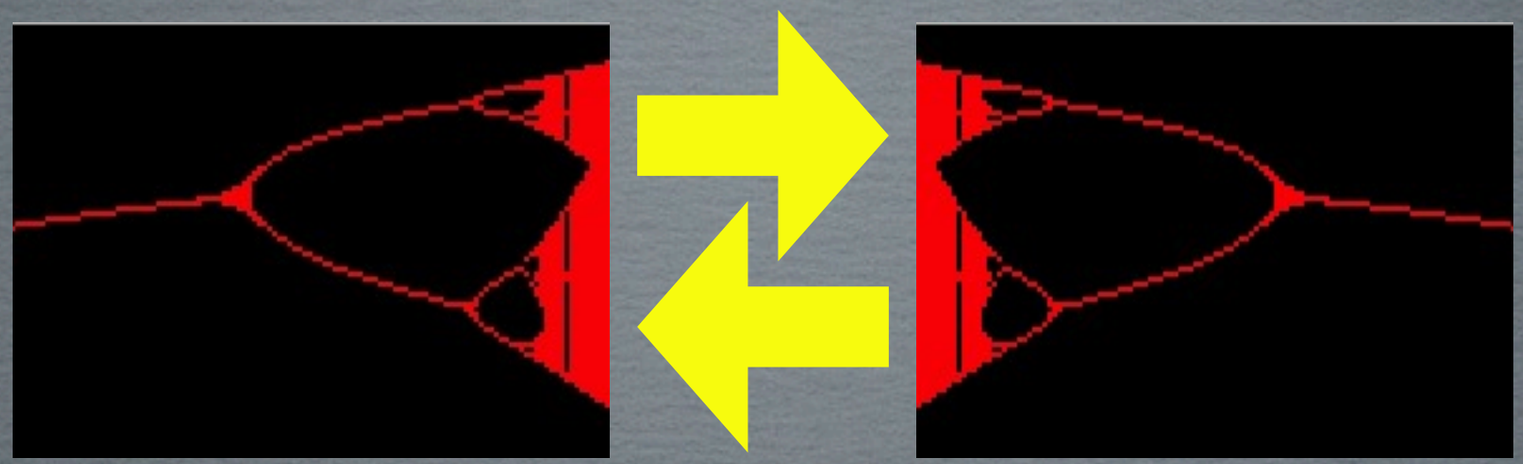
Cultural Ecologies

- Tibetan ---
  - Predators: Tibetans, Yaks
  - Prey: Barley, Wild grass & lichen
- Nepali ---
  - Predators: Nepalis, Dzos
  - Prey: Rice, Salt, Hay & grain

Essential Understanding

- A trade route is a bidirectional link between two cultural ecologies

- The full system comprises two coupled oscillators, like a double pendulum



Trade System

End of Lecture Four of Ten