Wetlands as stabilizing components in catchments

Jan Vymazal
ENKI, o.p.s.

Wetlands play important role in regional hydrology

In those catchments with intensive land use, they perform a key function in hydrological regulation and mass cycling

In recent decades, there have been many studies on the ecological values of natural wetlands and many protection measures have been proposed.

In addition to natural wetland, also semi-natural wetlands play an important role in catchment stabilization and functioning

Examples of semi-natural wetlands are irrigation ponds, water gardens, reed beds, fishponds. The semi-natural wetlands were and are still usually closely related to food production, so that they were mostly distributed in the areas with extensive agricultural activities, such as rice or fish production.

However, agriculture and wetlands have not always had a very harmoniuos relationship.

The need to expand agriculture to feed a growing population led in many places to a major conversion of wetlands into farmland

Large area of reed wetlands converted into farm land, in Baiyangdian Lake, China

However, agriculture and wetlands have not always had a very harmoniuos relationship.

The need to expand agriculture to feed a growing population led in many places to a major conversion of wetlands into farmland

Worldwide, this led to the well known, often quoted estimate that 50% of the world´s wetlands have been lost to agriculture and urbanization in the 20th century

Examples (de)stabilization role of wetlands in the landscape

Multipond system in agricultural area in China: wetland benefits

Florida Everglades: wetland loss through combination of urbanization and agriculture

Cahora Bassa, Mozambique: impact of dams on wetlands

Wetlands in south Iraq: destruction of wetlands = destruction of economy

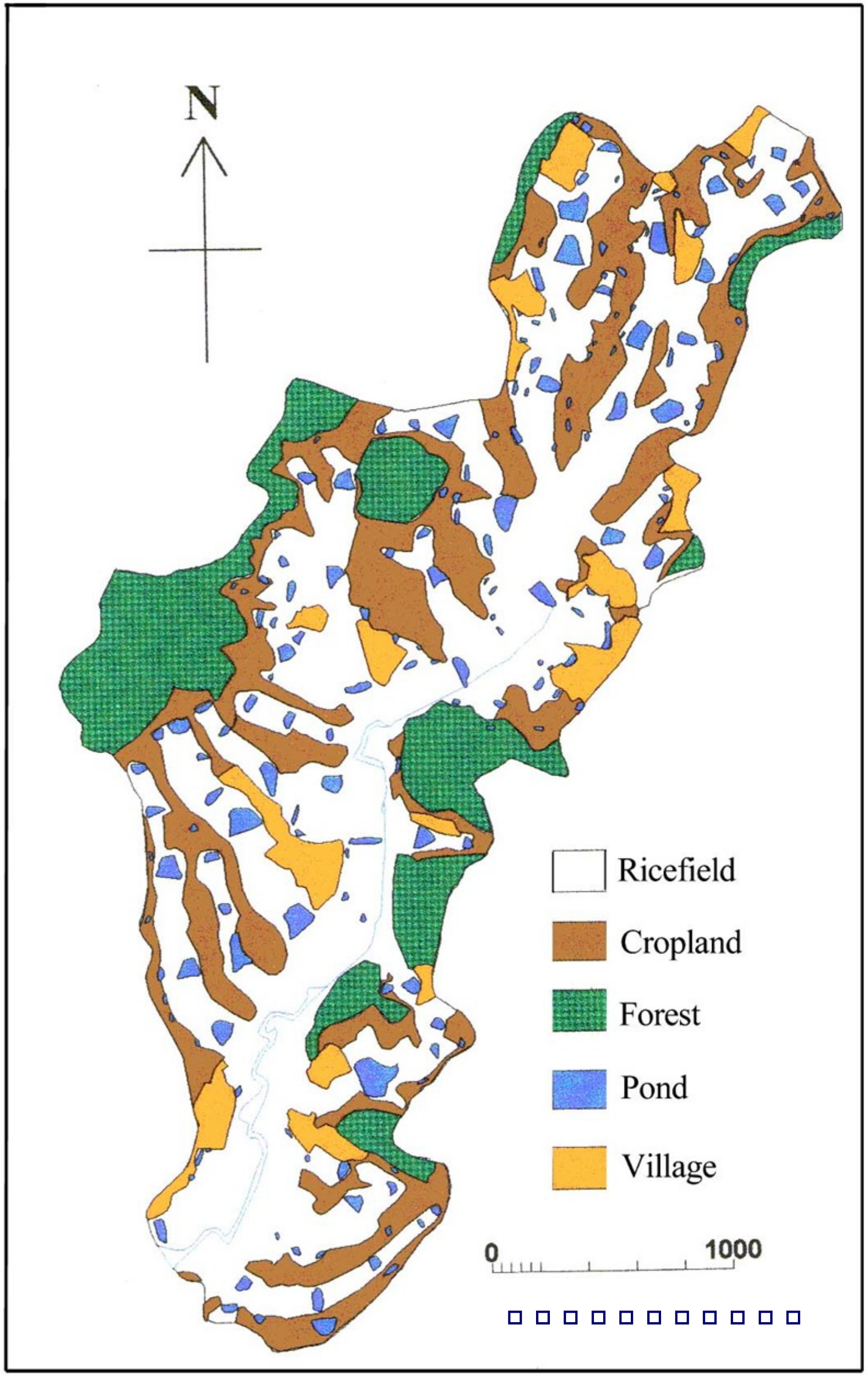
Multipond Systems (China)

Courtesy Chengqing Yin, Research Center for Eco-Environmental Sciences, Beijing China

- **The multipond system is composed of many tiny ponds**
- **They are scattered in agricultural fields**
- **Their area is 6 to 10% of the total watershed**
- **Low cost and easy management**
- **With more than 2000 years of use and development**

Ecological Functions of Multipond systems

- Regulation of water resource for crop water requirement
- Recycling of water and nutrients in land
- Reduction of nutrient load to waters
- Control of flood
- Reduction of drought
- Increase of biodiversity
- Decrease of sediment load to waters



A case study

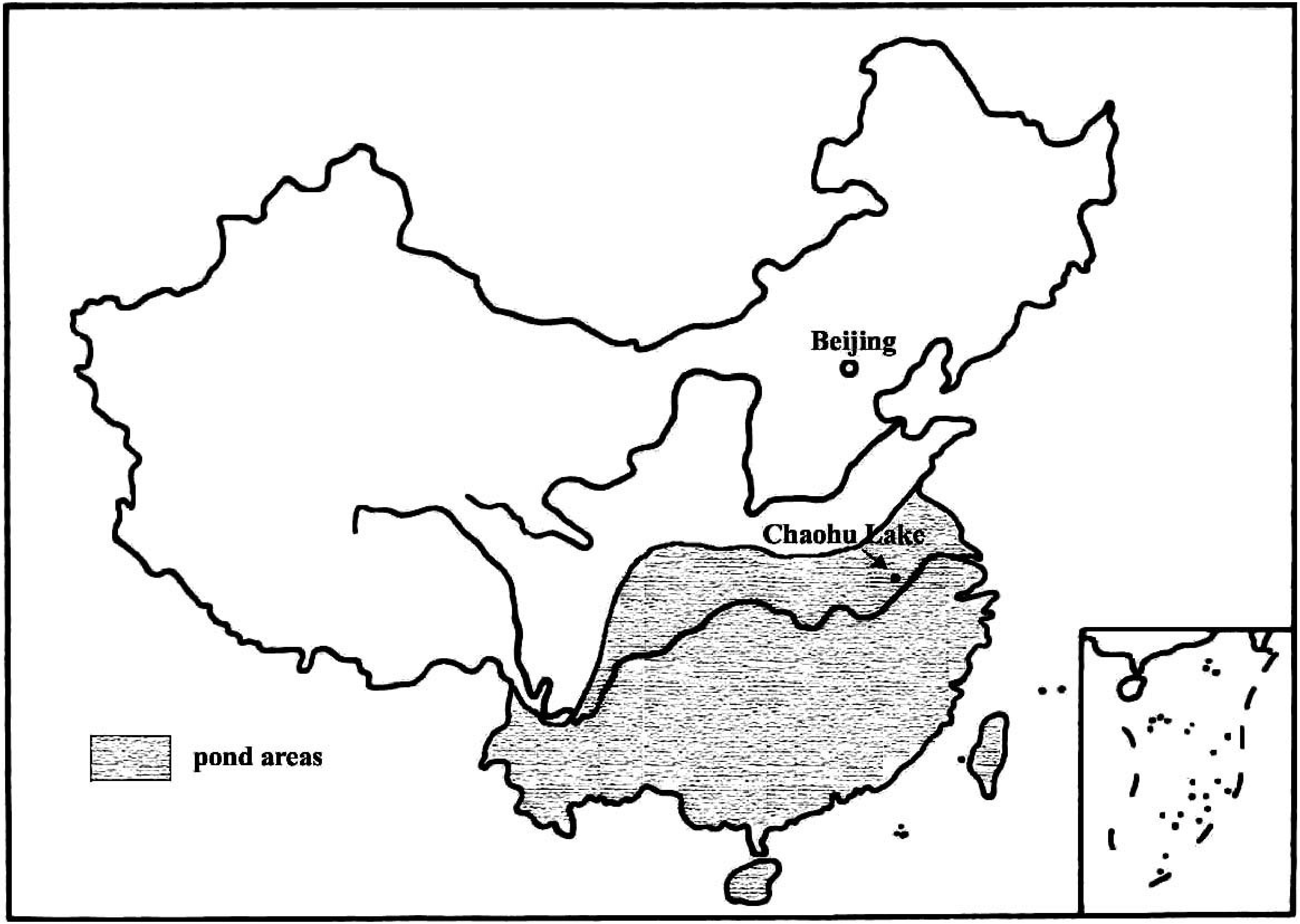
Liuchahe Watershed

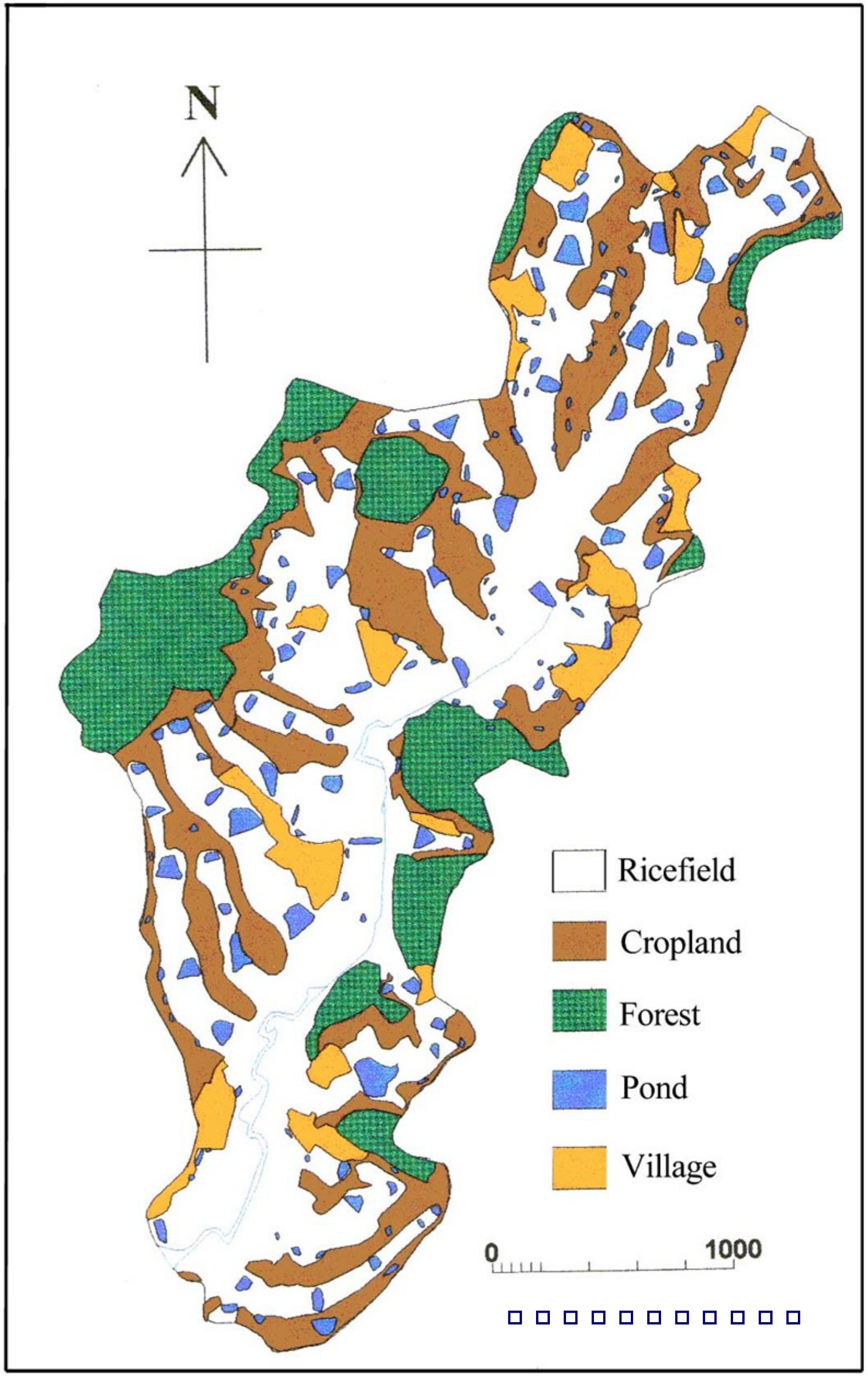
along a stream flowing into Chaohu Lake

Total area: 691.6 ha

5 land use types:

•Village	49.6ha	7.2%
•Forest	108.7ha	15.7%
•Ponds	43.2ha	6.2%
•Dry land	177.8ha	25.7%
•Paddy	312.3ha	45.2%


Beijing
Chaohu Lake
pond areas



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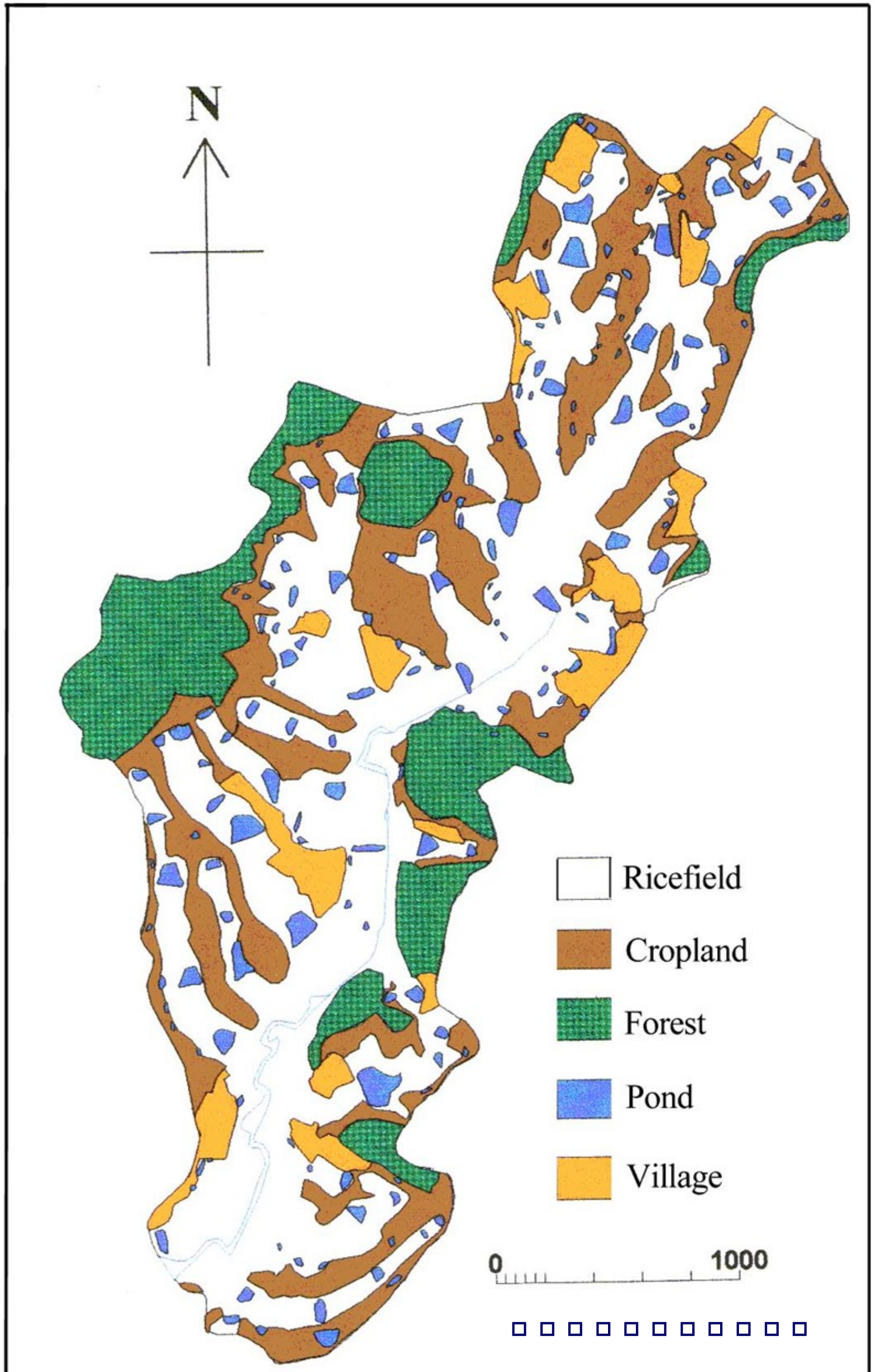

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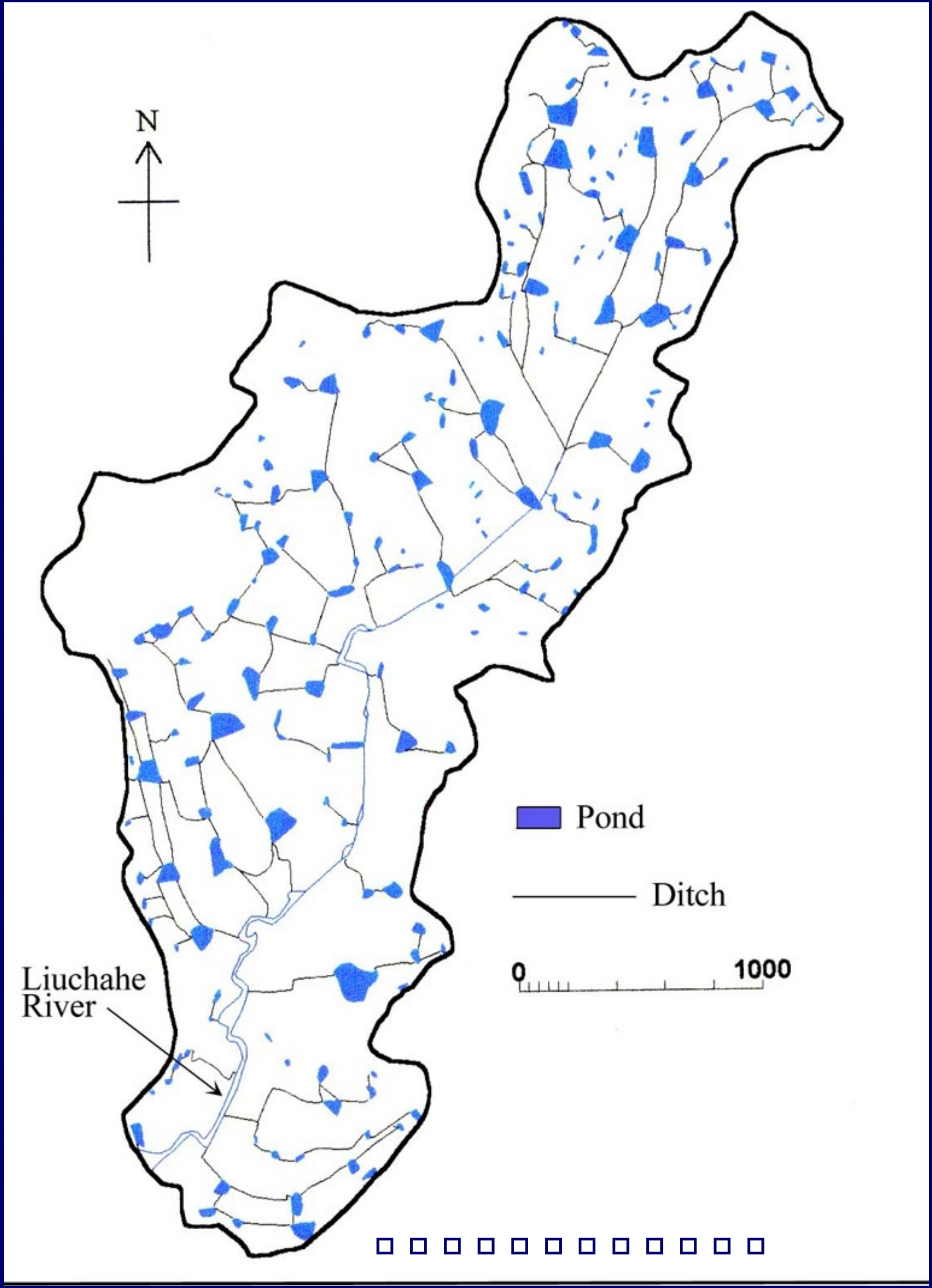
Multipond System in Liuchahe

Watershed area: 6.9 km^2
Pond number : 193
Mean pond area: 1976 m^2
Pond density : 28/100 ha
Ditch density : 33.8 m/ha
Mean depth : 1.5 m



Multipond Systems

Vegetation in ponds

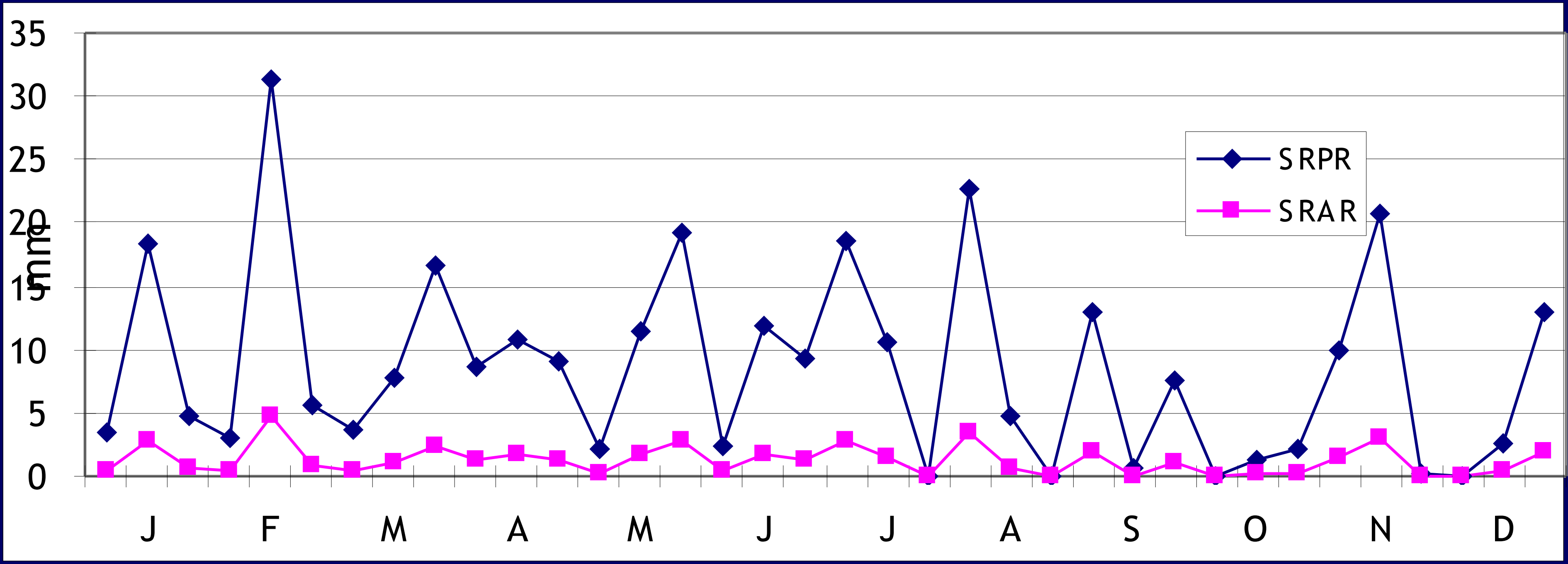
Grass at the ditch sides has a large filtration effects

Dry Ponds to Receive Runoff after Storms

Storage capacity: 94 mm runoff depth in Liuchahe Watershed

Total pond volume: $6.47 \times 10^5 m^3$

The effect of the multipond systeme on surface runoff in a normal rainfall year 1990



Annual surface runoff retention:

79% in a normal year (915 mm precipitation)

47% in a wet year (1174 mm)

84% in a dry year (668 mm)

Retention Efficiency of Multipond System to Control NSP

- **Reduction of runoff pollution by multipond systems:**

  97 % in 1987

  98 % in 1988

  99 % in 1994

  97 % in 1995

  94 % in 1999

P and sediment accumulation in multipond system (dry w)

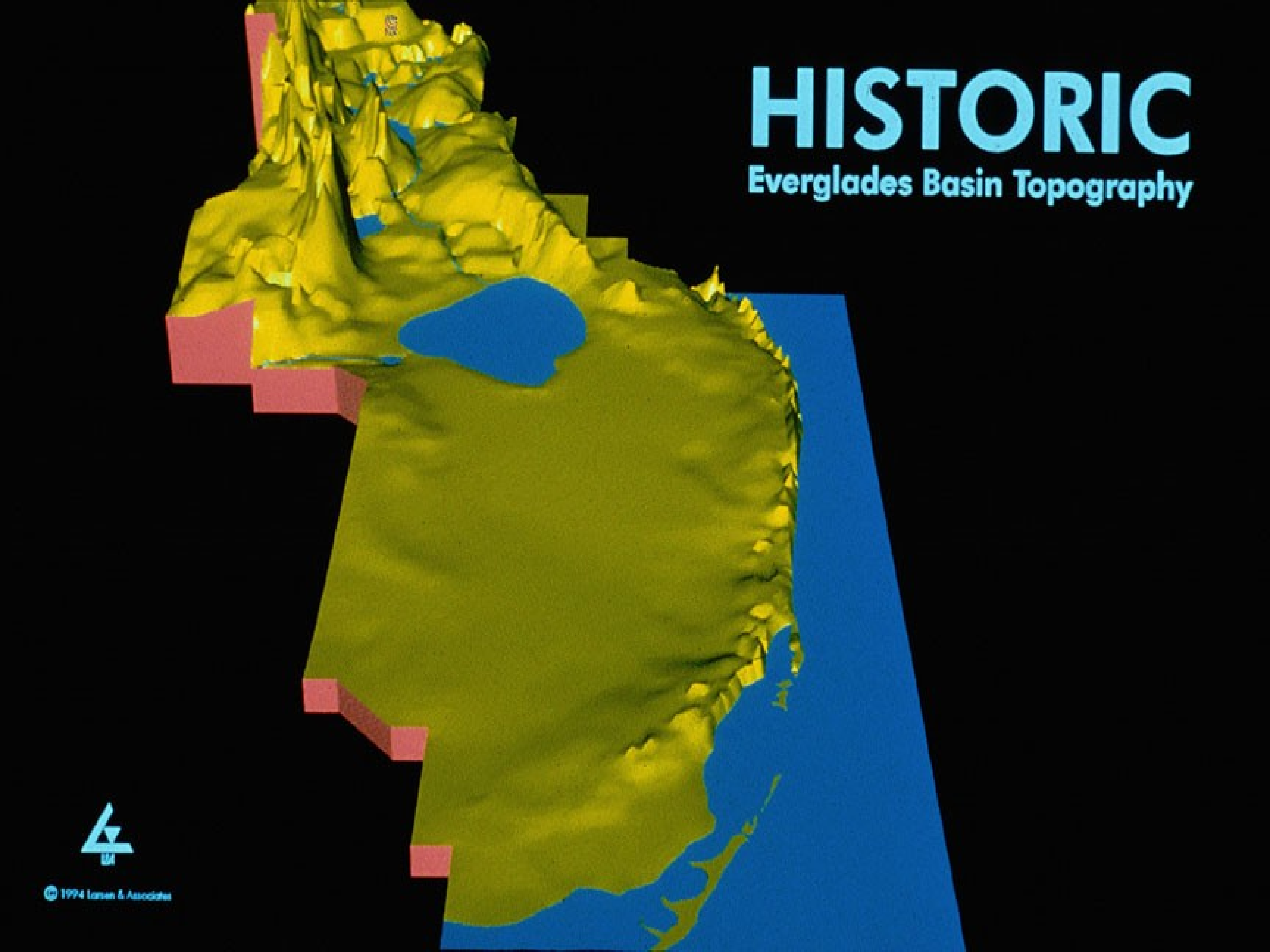
Type	Area (ha)	Sediment-ation (cm yr^{-1})	P cont. (g kg^{-1})	Density (g cm^{-3})	T. P kg yr^{-1}	Sediment kg yr^{-1}
Village Po	1.85	5	0.76	1.10	773	1.02×10^6
Field Po	37.5	3.5	0.47	0.97	5984	12.73×10^6
Mount Po	3.8	1.2	0.39	1.03	183	0.47×10^6
Ditch	0.92	1.4	0.49	1.21	76	0.16×10^6
				Total	7016	14.38×10^6 kg yr^{-1}

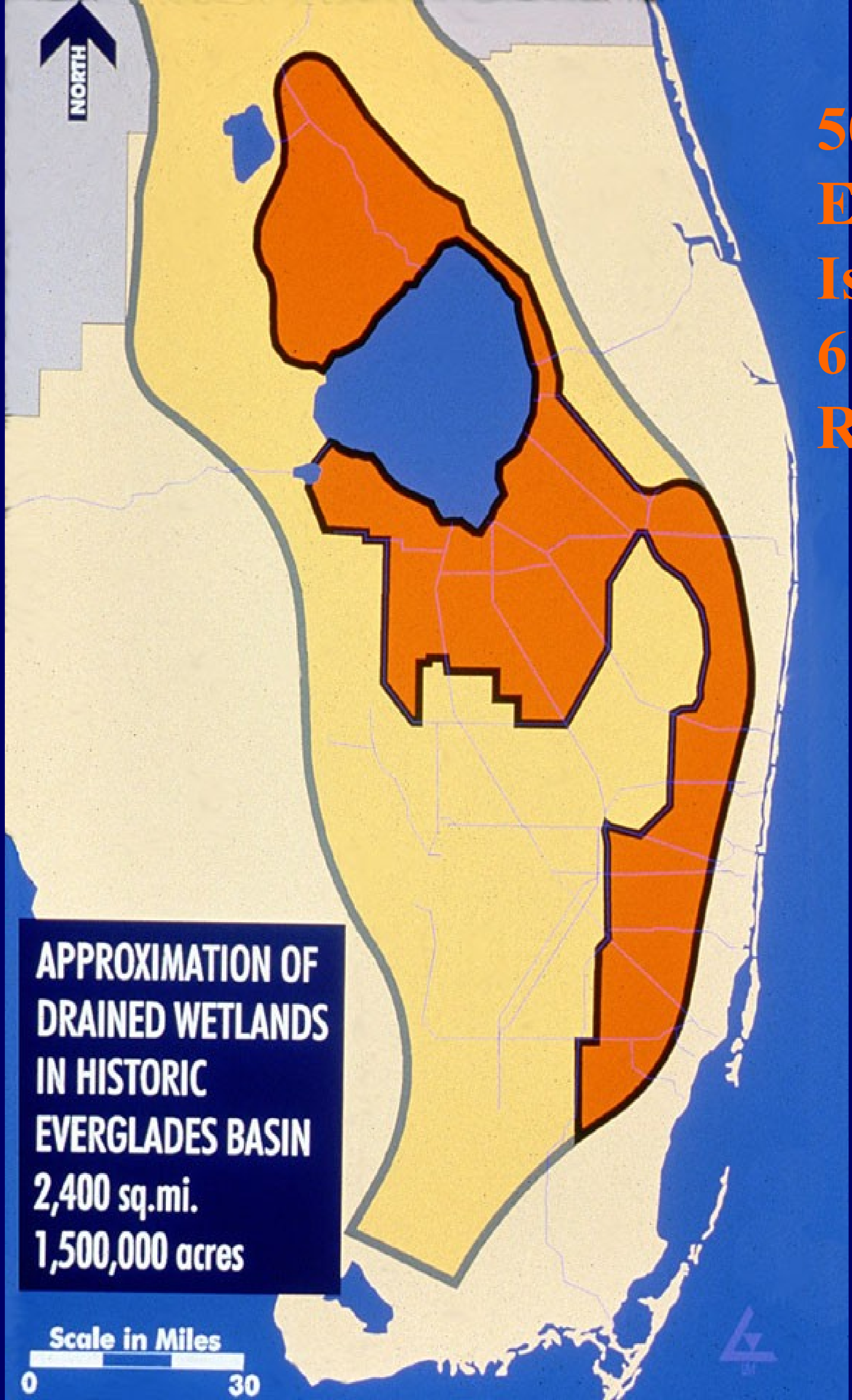
Mechanisms of multipond system retention

- Interception of runoff, 25-60mm/d
- Recycling of water, each irrigation event consumes 50 % water in the ponds
- Sedimentation of particulate nutrients
- Adsorption of nutrients by pond sediments
- Uptake by pond plants and harvest of plants

The Everglades

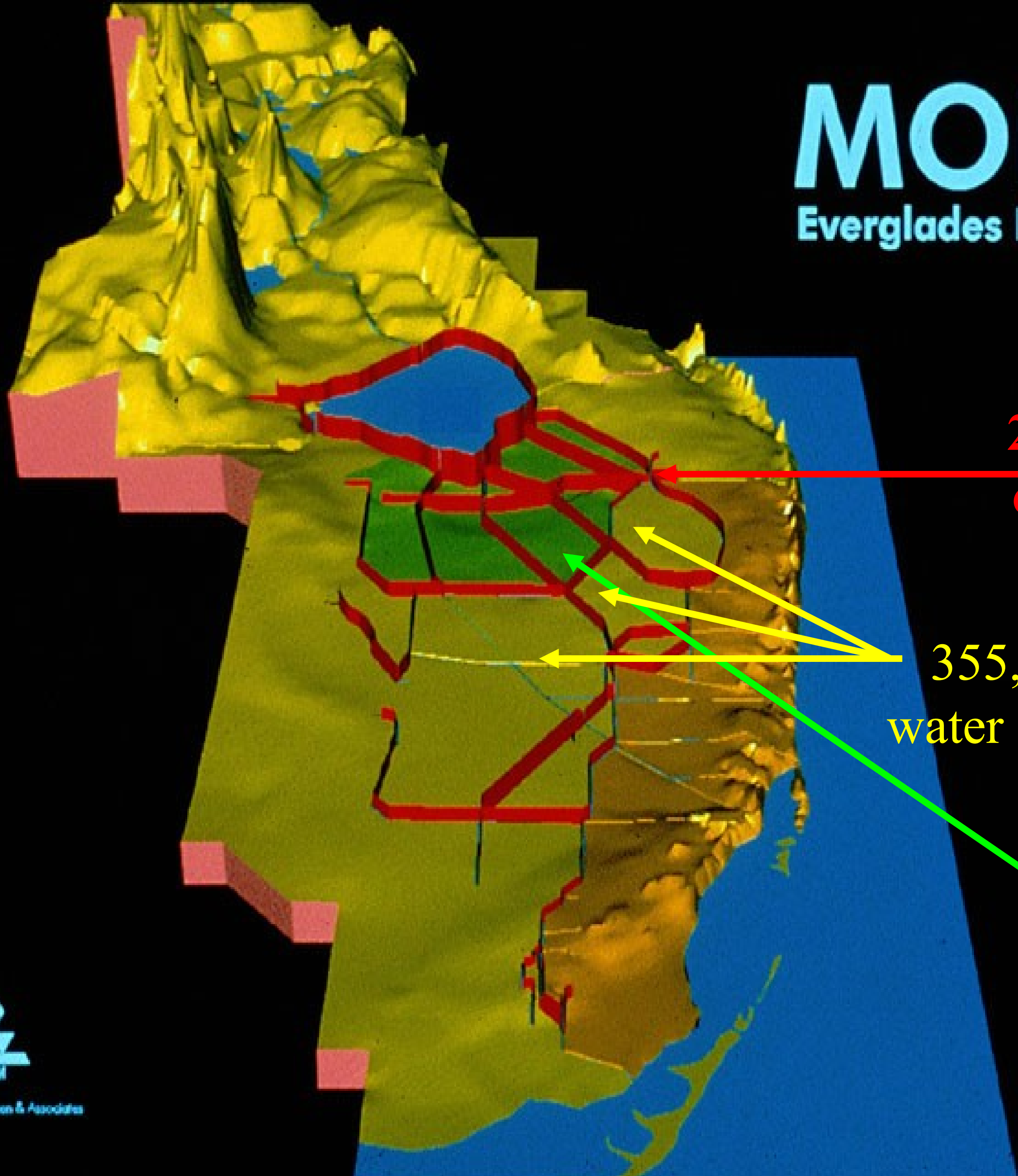

The Everglades
Lake Okeechobee
Everglades


HISTORIC
Everglades Basin Topography



50% of the Everglades Is Developed and 618, 000 ha Remain

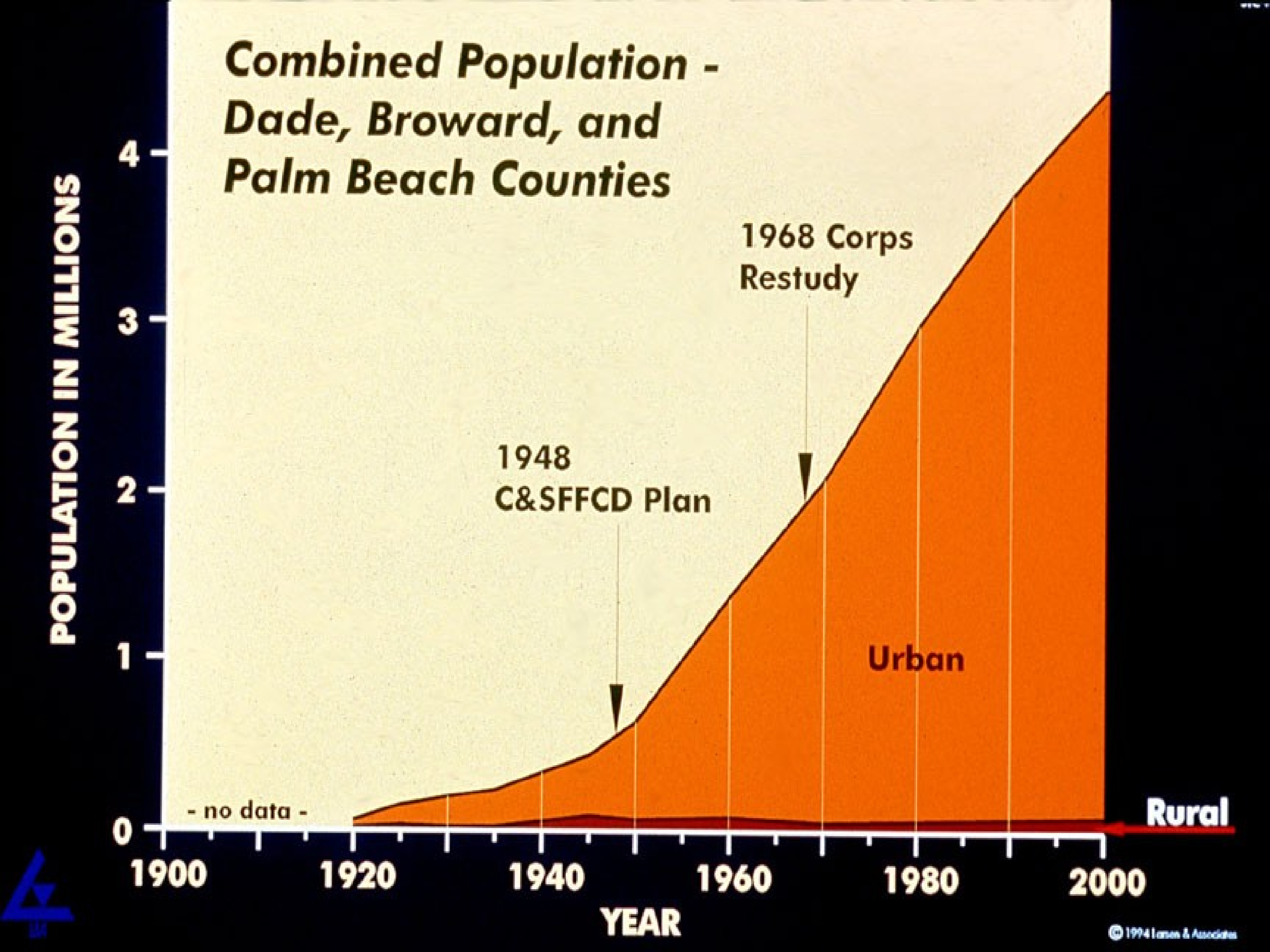
MODERN
Everglades Basin Topography

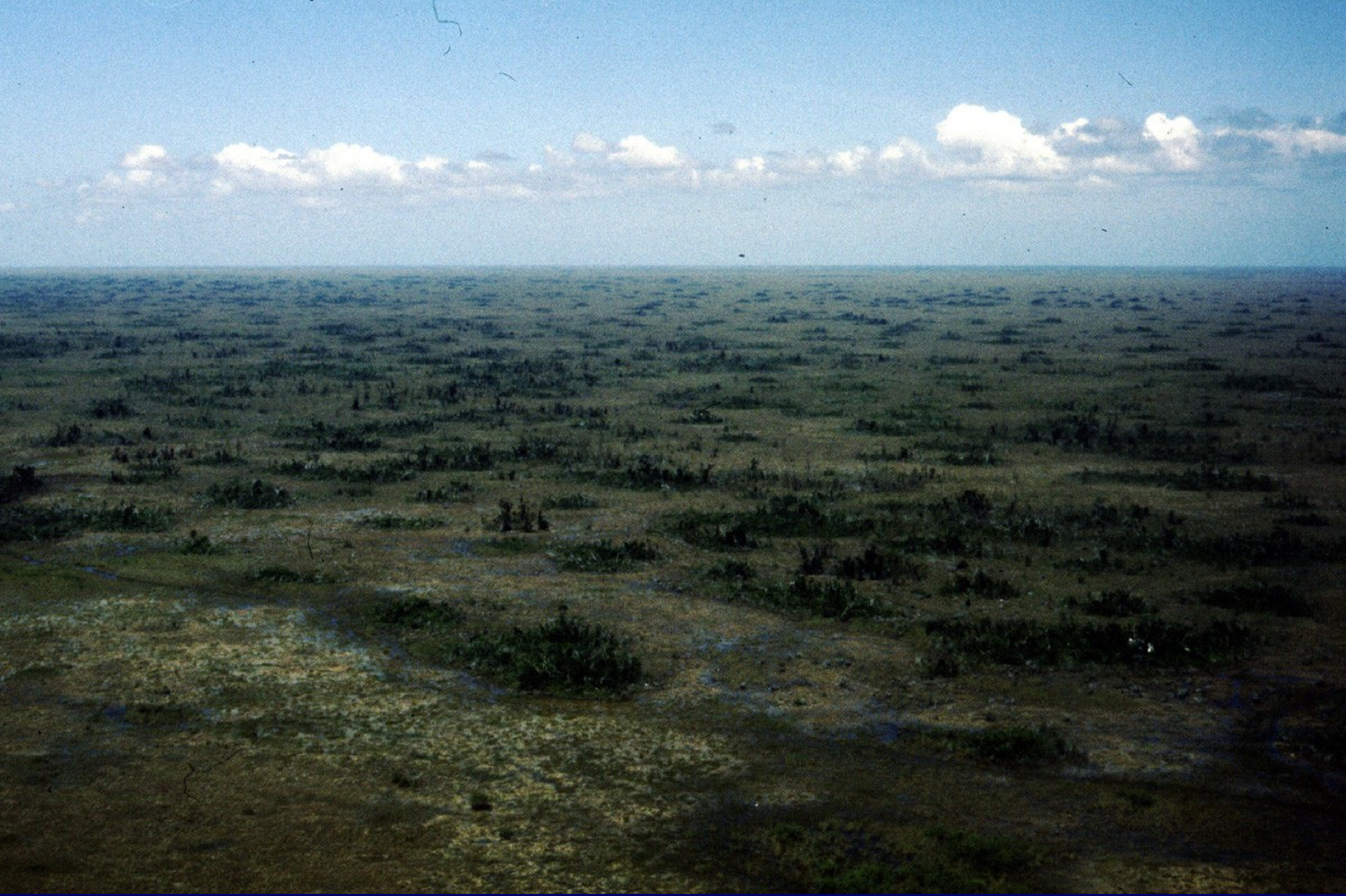


2000 km of canals and ditches

355,550 ha of diked water conservation areas

181,000 ha of Agricultu re


Combined Population -
Dade, Broward, and
Palm Beach Counties
POPULATION IN MILLIONS
0
1
2
3
4
- no data -
1948
C&SFFCD Plan
1968 Corps
Restudy
Urban
Rural
1900
1920
1940
1960
1980
2000
YEAR



Monotypic stands of sawgrass (*Cladium jamaicense*)
in unimpacted areas

Stands of *Typha domingensis* (Cattail) in phosphorus-enriched areas

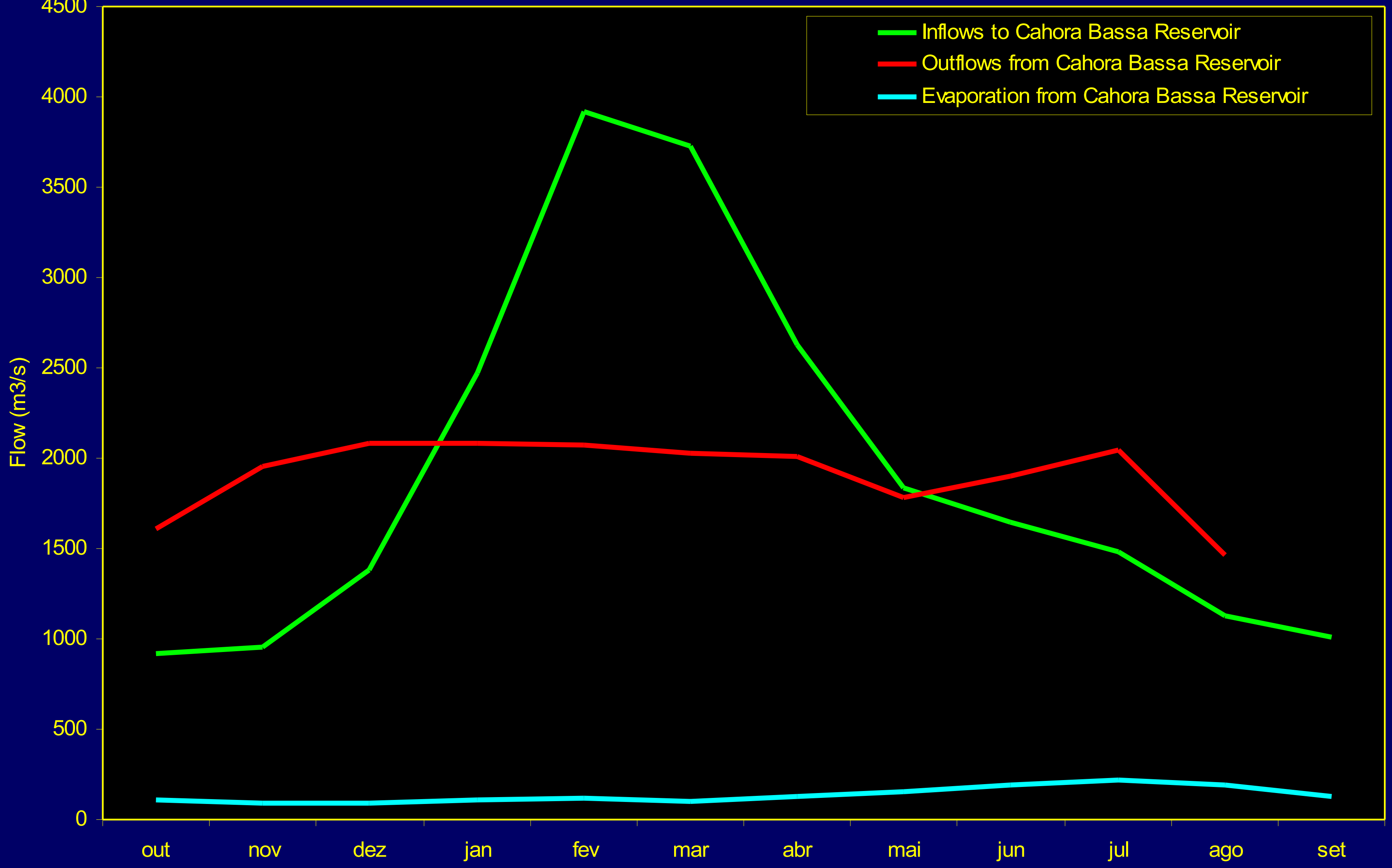
d Area

Cahora Bassa, Mozambique

Impact of dam construction on Zambezi delta ecosystem


ANGOLA
Kalene Hill Mission
Zambezi
Mwinilunga
West Lunga
Chavuma
Zambezi
Lunguevungu
Kabompo
WEST LUNGA NATIONAL PARK
Kafue
Lunga
LIUWA NATIONAL PARK
Lukulu
Kwando
Luanginga
LUENA FLATS
Luena
Mongu
ZAMBIA
NORTH LUANGWA NATIONAL PARK
SOUTH LUANGWA NATIONAL PARK
Luangwa
Lunsemfwa
INTERNATIONAL GAME PARK
KAFUE NATIONAL PARK
Lusaka
Itezhe-Tezhi
Kafue
Senanga
LOCHINVAR NATIONAL PARK
Sioma
Kariba
Chirundu
Luangwa
Zumbo
Cahora Bassa
Songo
Tete
MANA POOLS NATIONAL PARK
MALAWI
Malawi
Lilongwe
Shire
MAJETE NATIONAL PARK
LENGWE NATIONAL PARK
MOZAMBIQUE
Sesheke
Kazungula
Livingstone
Kariba
MATUSADONA NATIONAL PARK
Sanyati
Umi
Katima Mulilo
CAPRIVI NATIONAL PARK
Chobe
Binga
Victoria Falls
CHIZARIRA NATIONAL PARK
Harare
Mopeia
Marromeu
Chinde
MARROMEU BUFFALO RESERVE
GORONGOSA NATIONAL PARK
Gwai
CHOBE NATIONAL PARK
HWANGE NATIONAL PARK
MOREMI NATIONAL PARK
NAMIBIA
ZIMBABWE
Beira
MAKGADIKGADI PAN NATIONAL PARK
BOTSWANA
N
KEY TO MAP
TRAVEL BY RIVER
TRAVEL BY ROAD
TRAVEL BY AIR
INTERNATIONAL BOUNDARY
NATIONAL PARK
INDIAN OCEAN

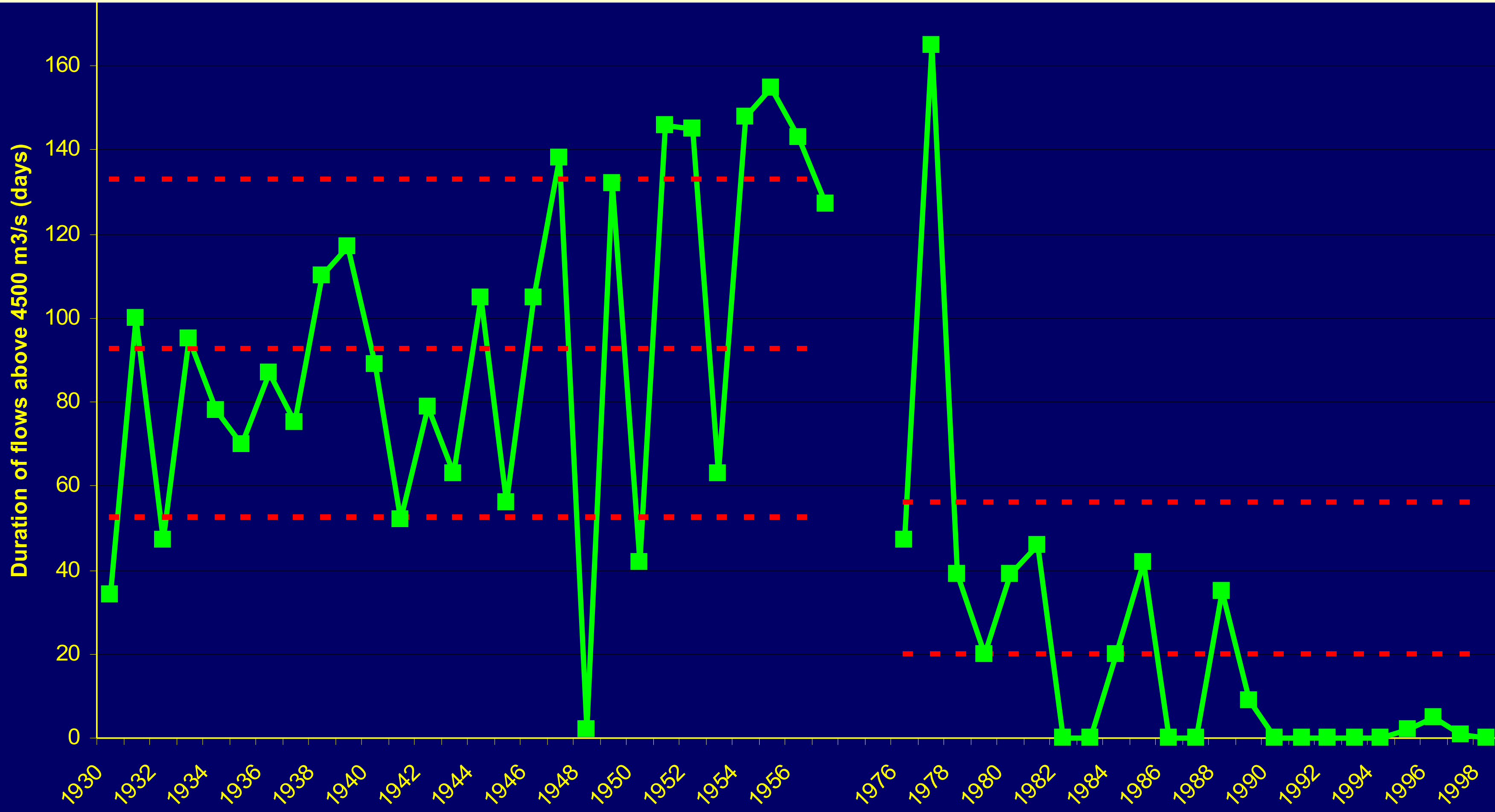
Impact of Cahora Bassa dam on the magnitude and timing of flows in the lower Zambezi (1975-2000)



1929


2000

Duration of inundation in the Zambezi Delta (corresponding to flows greater than 4500 m³/s) under historical conditions (1930-1958) and since construction of Cahora Bassa Dam (1975-2000)



Significant changes in vegetation cover in the Zambezi Delta, 1960-2000

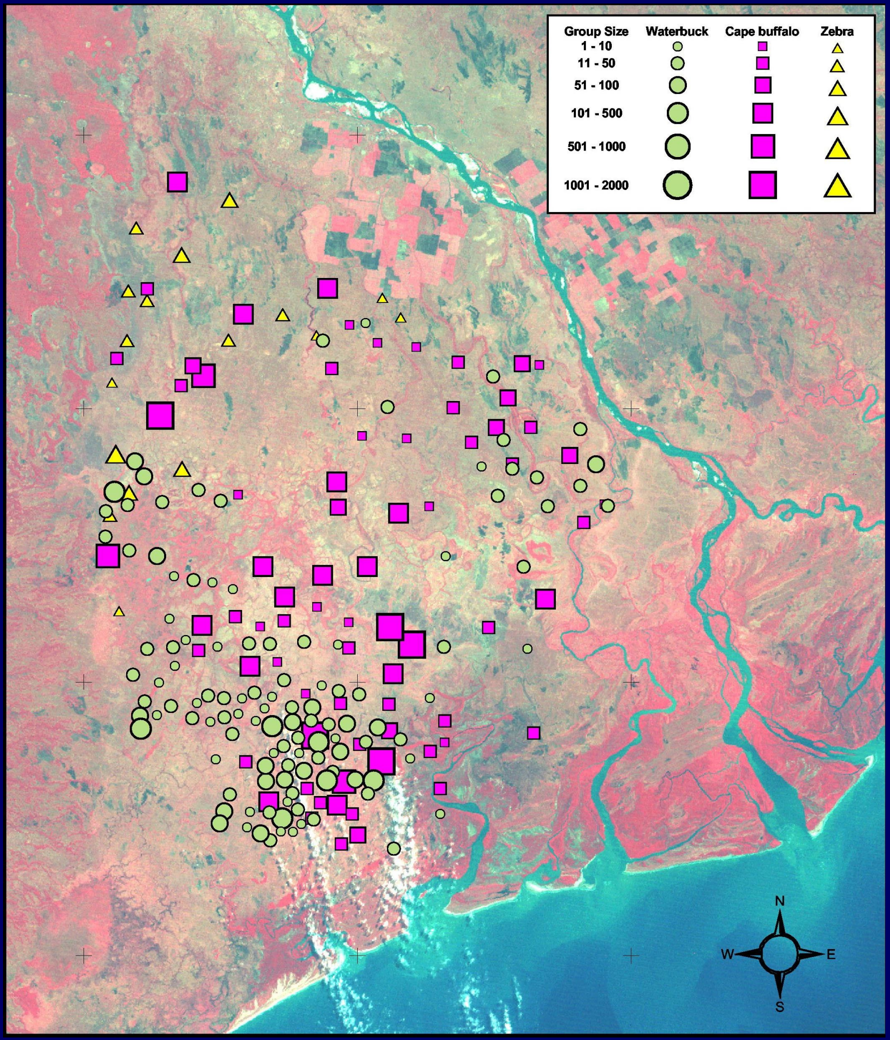
Vegetation classification unit	Area in hectares			
	1960	2000	change	%change
Acacia thicket on delta floodplain	40000	45000	5000	13
Acacia savanna on delta floodplain	113000	140000	27000	24
Borassus palm savanna on the delta floodplain	9000	8000	-1000	-11
Hyphaene palm savanna on delta floodplain	72000	86000	14000	19
Hyphaene palm savanna and associated species on outwash sands	29000	34000	5000	17
Secondary grassland/savanna/thicket on the channel shelf and levee	28000	31000	3000	11
Seasonally wet tussock grassland mosaic on delta floodplain	158000	122000	-36000	-23
Perennially wet stoloniferous grassland mosaic on delta floodplain	125000	118000	-7000	-6
Papyrus and deepwater swamps in permanently flooded channels	91000	84000	-7000	-8
Saline grassland mosaic with Phragmites reedswamp	127000	133000	6000	5

Negative impacts on floodplain vegetation and waterways

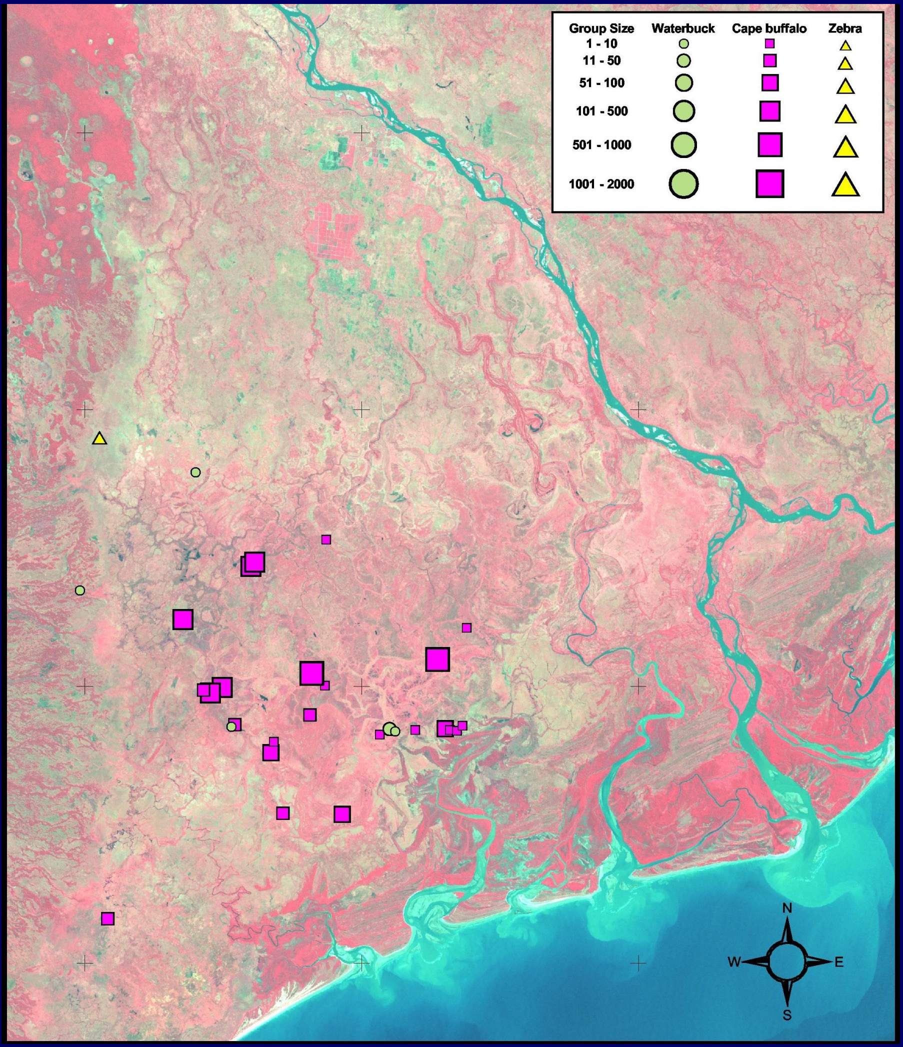
Negative impact on the productivity of subsistence fisheries

Negative impact on the coastal prawn industry

Negative impact on water-dependent fauna



1969



2000

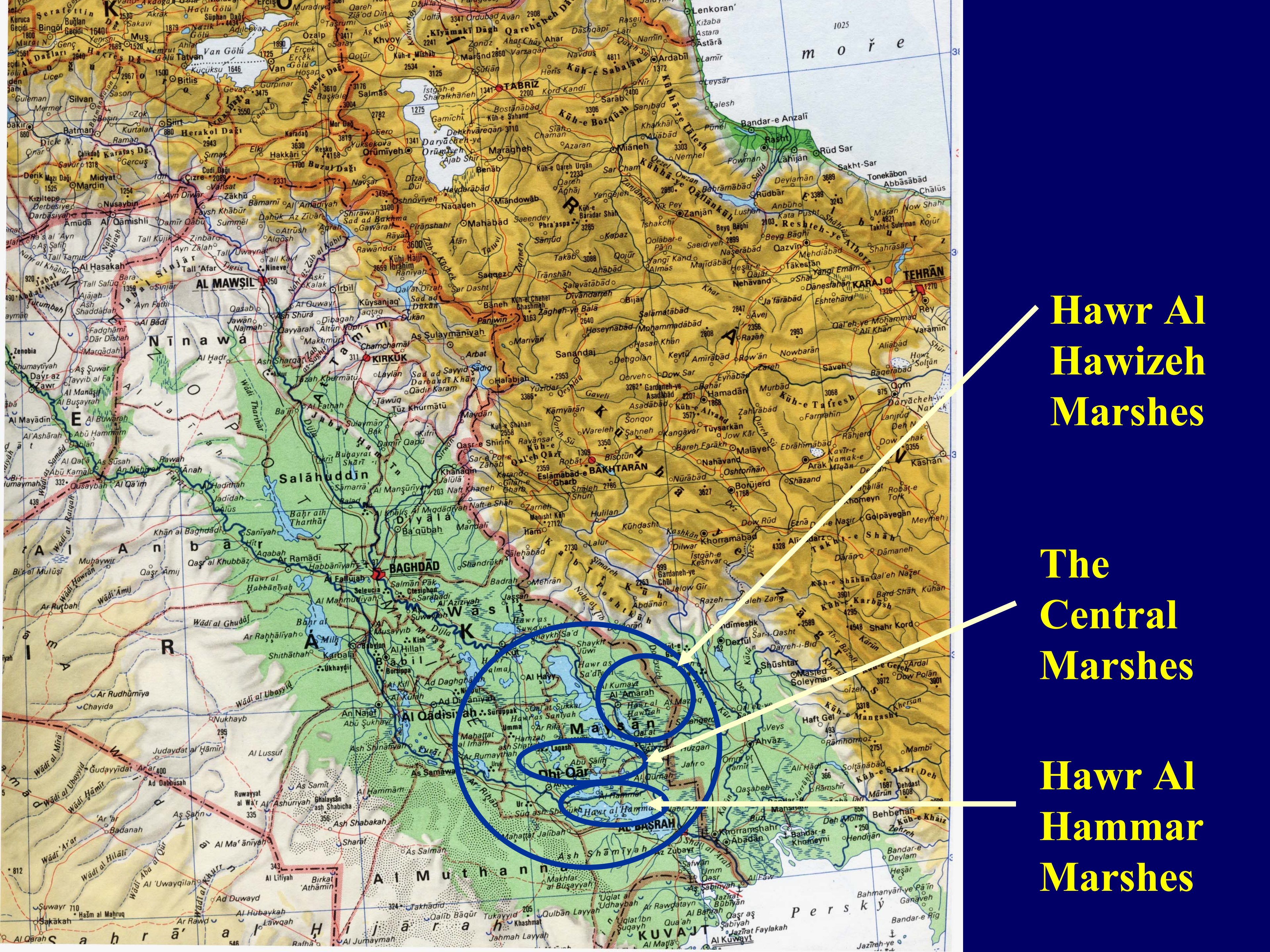
Negative impact on the carrying capacity of the Zambezi Delta for wildlife

Negative impact on globally endangered species

Negative impact of human encroachment on the floodplain results in severe damage and resettlement during large floods.

Wetlands in souther Iraq – Mesopotamian marshes

„Mass destruction“ of wetlands……with no benefits


Hawr Al Hawizeh Marshes
The Central Marshes
Hawr Al Hammar Marshes
BAGHDĀD
AL MAWṢIL
KIRKŪK
TEHRĀN
TABRĪZ
BAKHTARĀN
AL BAṢRAH
Maysān
Dhi Qār
Al Qādisīyah
Al Muthannā
Salāhuddīn
Nīnawā
Al Anbār
Wāsiṭ
Bābil
Diyālā
At Ta'mīm
Hawr al Hammar
Al 'Amārah
Karbalā'
An Najaf
Perský
moře

Area loss of Mezopotamian wetlands during 1973-2000 (km^2)

Wetland	1973-76	2000	2000 as % 73-76
Central			
Permanent wetlands	2 853	69.8	2.4
Permanent lakes	112	5.7	5.1
Seasonal/shallow lakes	156	22.5	14.4
Total	3 121	98.0	3.1
Al Hawizeh			
Permanent wetlands	2 715	837.4	30.8
Permanent lakes	186	129.4	69.4
Seasonal/shallow lakes	175	58.1	33.3
Total	3 076	1025.0	33.3
Al Hammar			
Permanent wetlands	1 675	27.9	1.7
Permanent lakes	362	88.7	24.5
Seasonal/shallow lakes	962	57.2	8.3
Total	2 729	173.9	6.4
Total wetlands	**8 926**	**1 296.9**	**14.5**

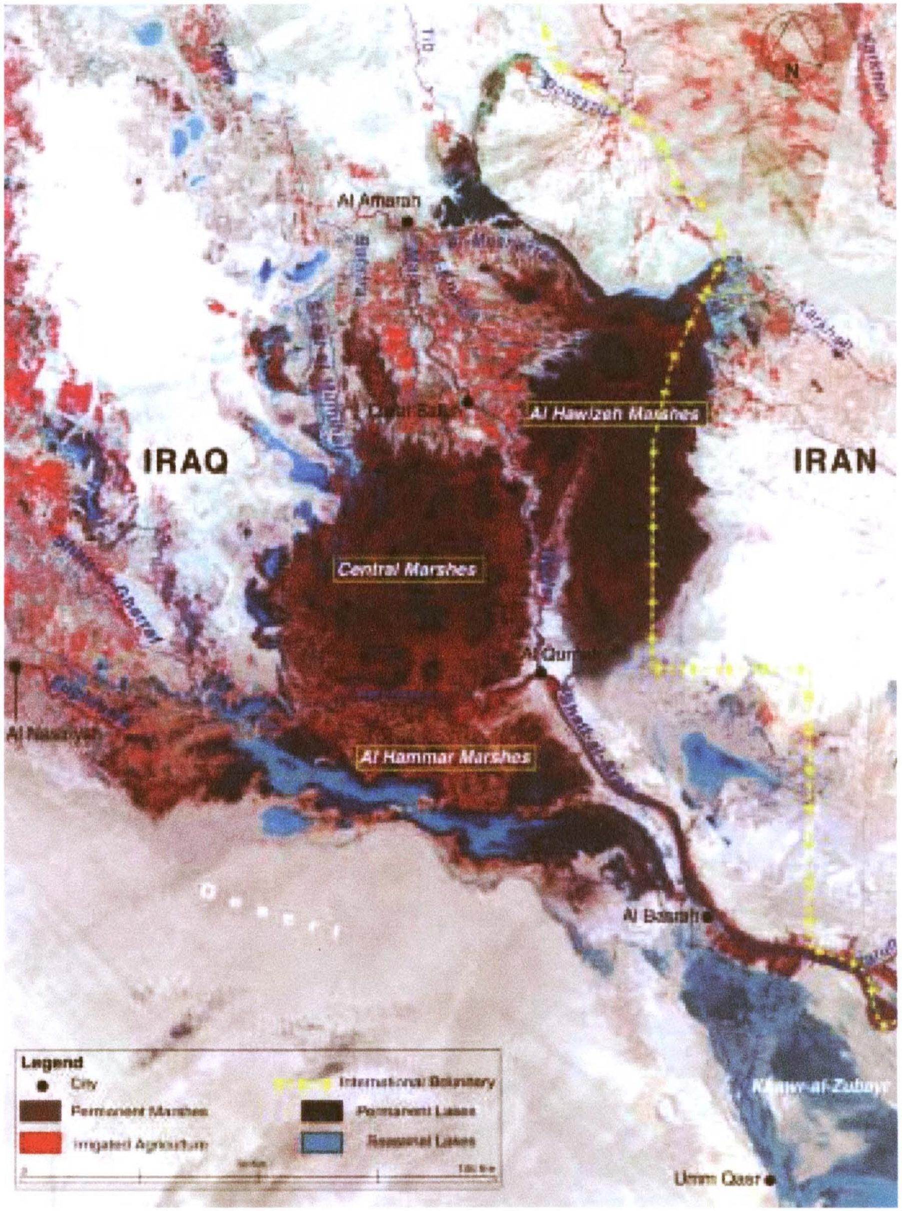


Fig. 4 - Space view of the Mesopotamian Marshlands taken by the earth observation satellite Landsat in 1973-76. Dense marsh vegetation (mainly *Phragmites*) appears as dark red patches, while red elongated patches along river banks are date palms. (Mosaic of four Landsat 1 and 2 false-colour, near-infrared images, Multi-Spectral Scanner (MSS) Bands 4, 2 and 1, taken on 16 February 1973, 14 February 1975 and 27 May 1976).

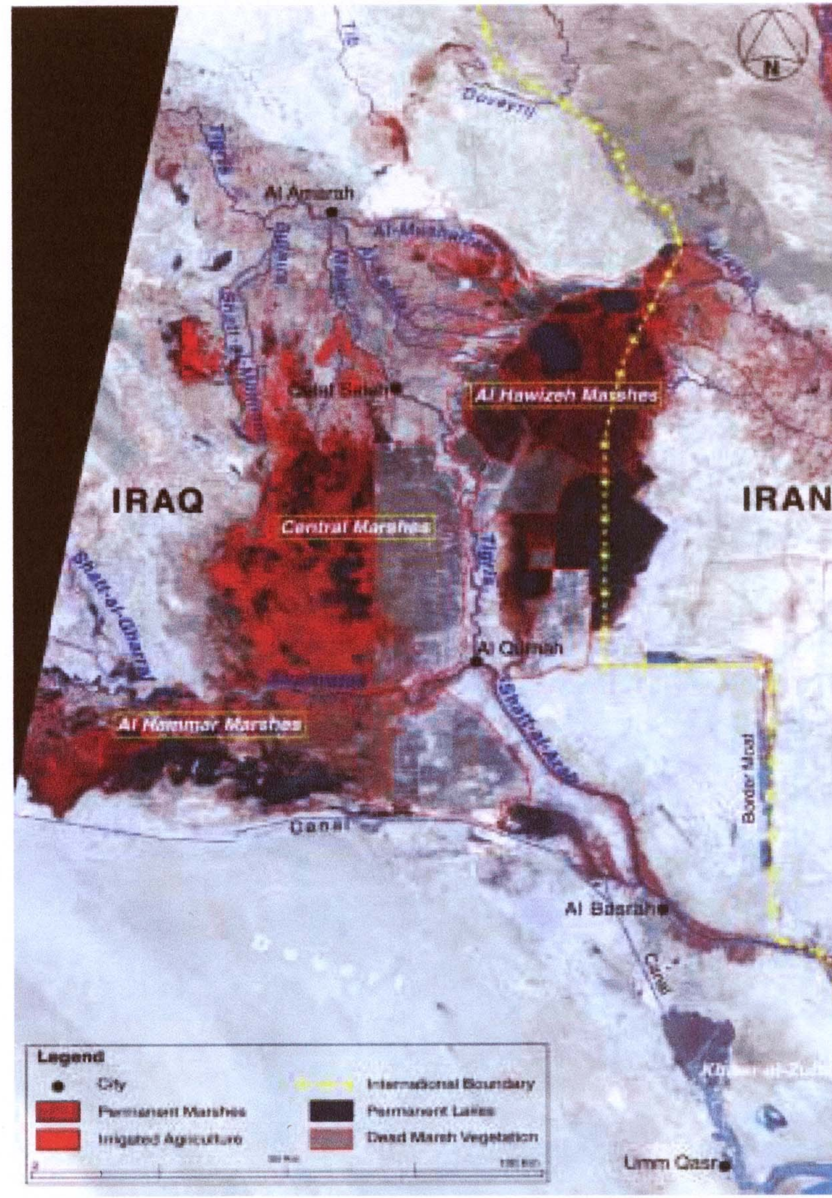


Fig. 15 - The marshlands in 1990 following the aftermath of the Iran-Iraq war. A large eastern swath of the Central and Al Hammar marshes as well as the northwestern and southern fringes of the Al Hawizeh marshes (red outline) had dried out by then as a result of the construction of causeways to ease military transport in an otherwise difficult terrain. (Mosaic of two Landsat 5 false-colour, near-infrared images, Multi-Spectral Scanner (MSS) Bands 4, 2 and 1, taken on 7 September 1990).

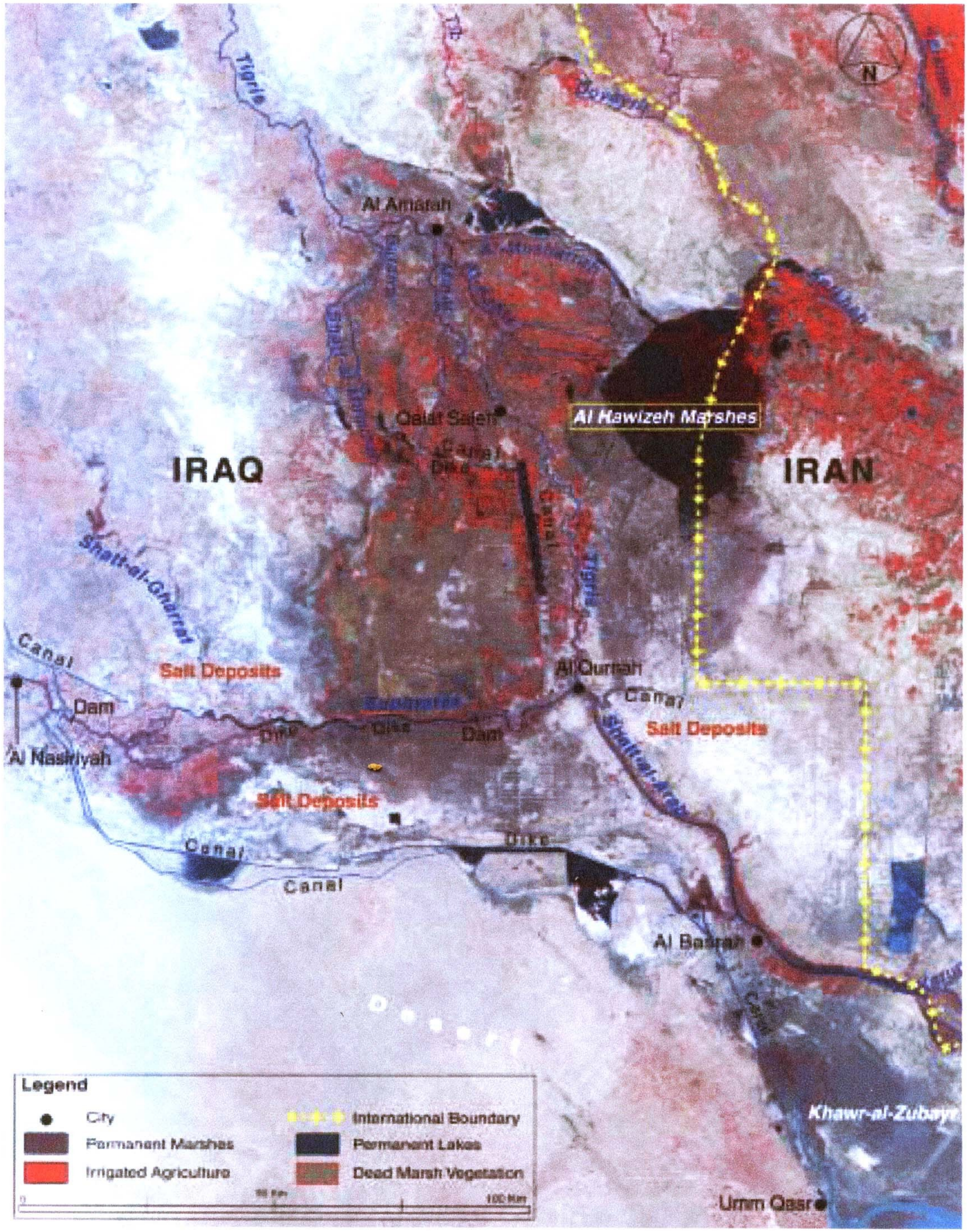
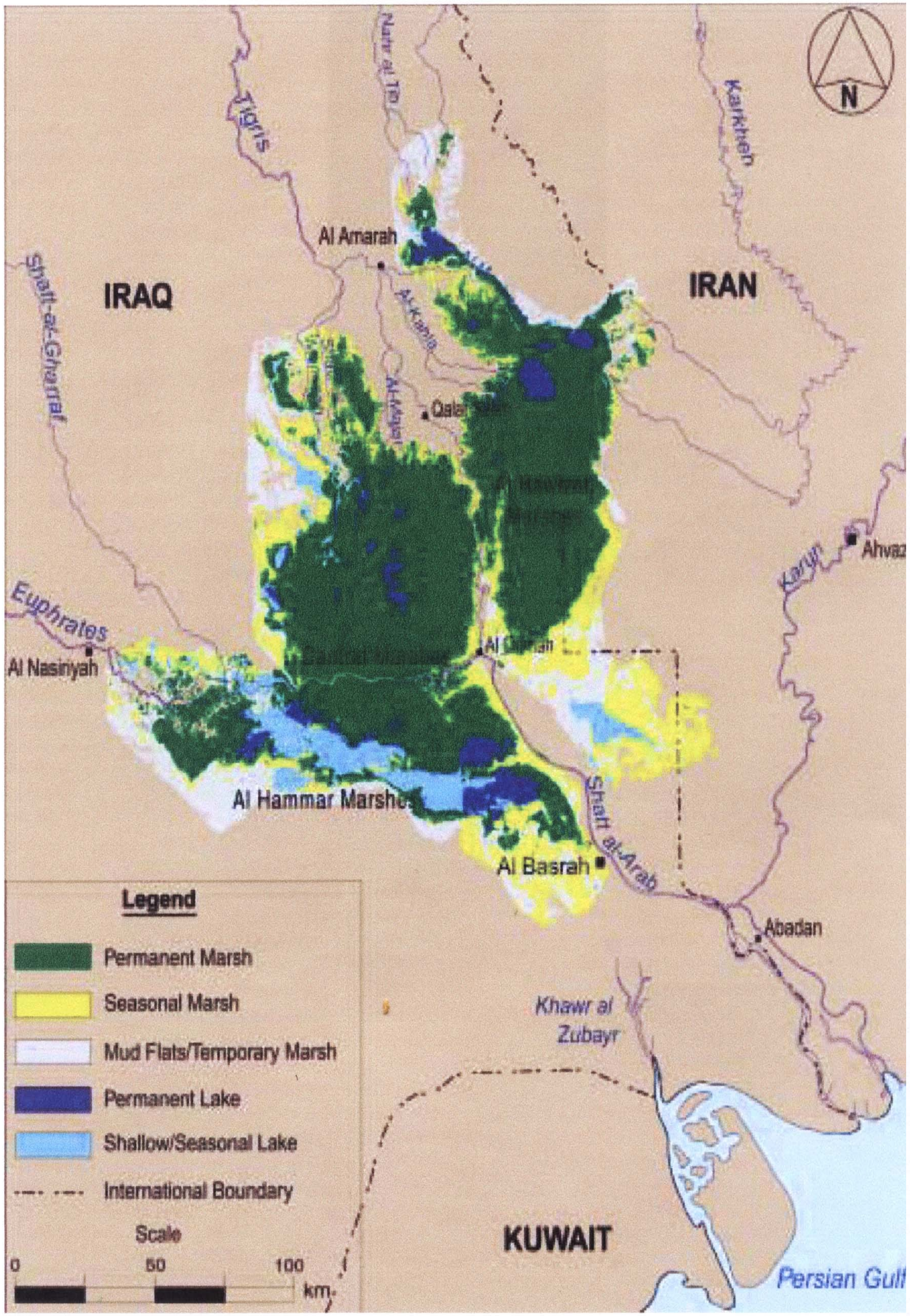
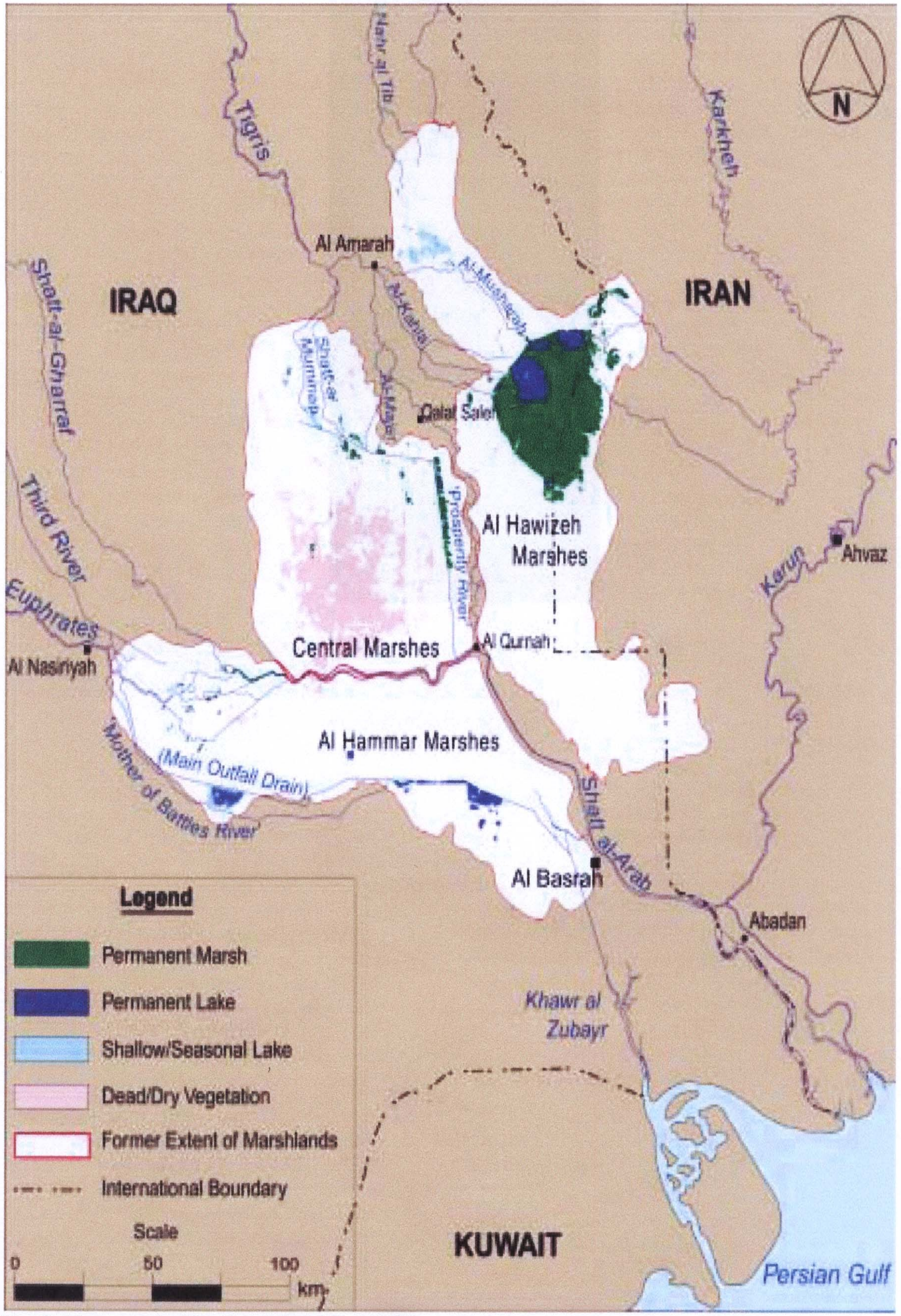


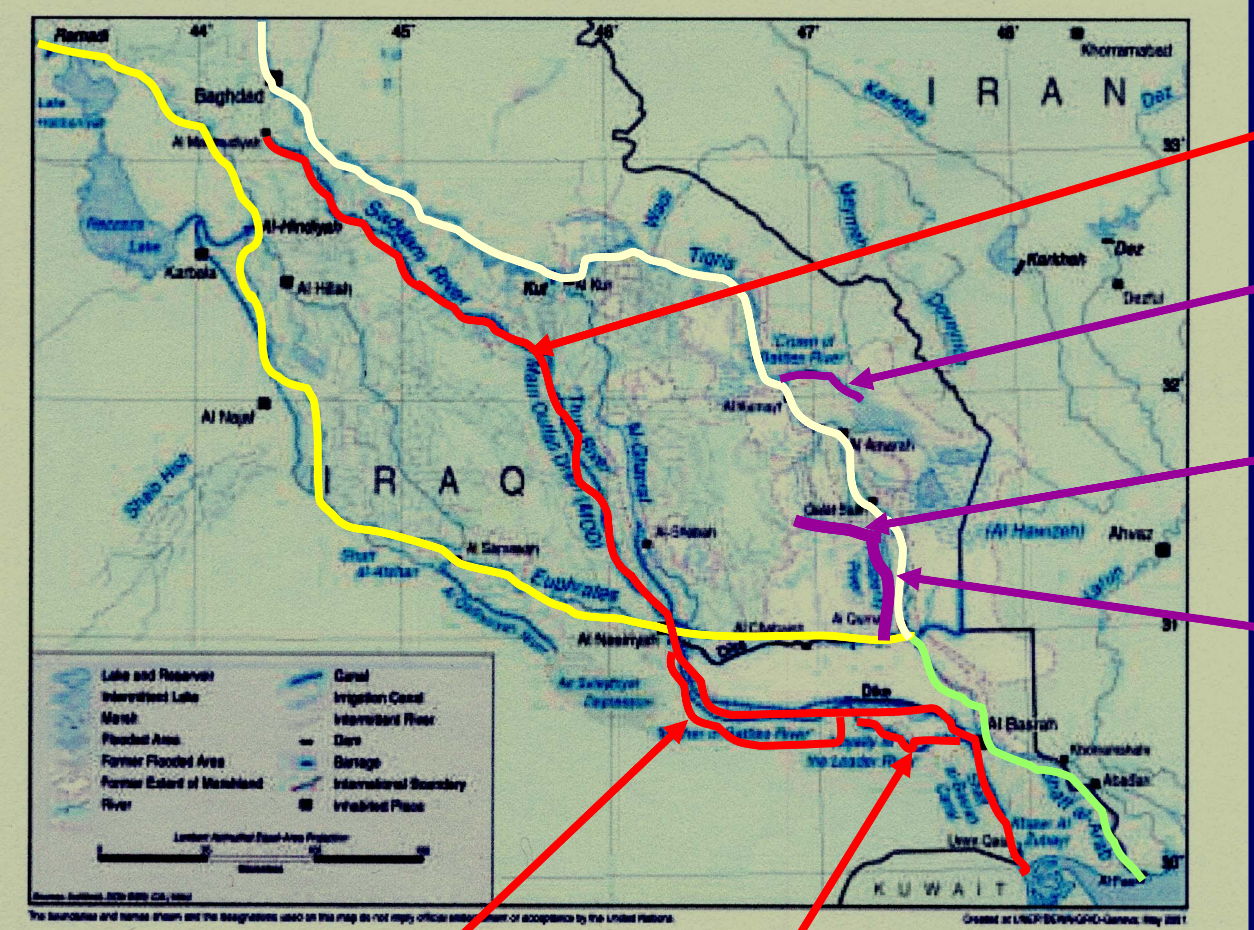
Fig. 18 - In this Landsat 7 Enhanced Thematic Mapper (ETM) mosaic taken in 2000, most of the Central Marshes appear as olive to grayish-brown patches (red outline) indicating low vegetation on moist to dry ground. The very light to grey patches are bare areas with no vegetation and may actually be salt evaporites of former lakes. (Mosaic of four Landsat 7 false-colour, near-infrared images, ETM Bands 4, 3 and 2, taken on 26 March and 4 May 2000).



Map 7 - Mesopotamian Marshlands: Land Cover 1973 - 76.



Map 8 - Mesopotamian Marshlands: Land Cover 2000



Map 6 - Drainage schemes in southern Iraq.

MOD=Major Outfall Drain, Third River, Saddam River, 1992, 565 km, 120-200 m³/s

Crown of Battles River, 1993 cca 50 km, 400 m³/s

Glory River, 1993, 40 km, 1.5 km wide

Prosperity River, 1993, 50 km, 2 km wide

MOB=Mother of Battles, 1993, 108 km, 400-600 m³/s

Loyality (Fidelity) to the Leader Canal, 1997, 90 km, 100 m³/s

Euphrates

Tigris

Shatt Al Arab

Present flow of Eufrat: 10-99 m³/s (mean 57 m³/s)


Main Outfall Drain (MOD)


Mother of Battles River


Loyality to the Leader Canal


Glory River

Prosperity River

Hawizeh – remaining wetlands

Hawizeh – drained areas


Central – original wetlands
(photo: Brian Whitton, 1976)

Central: drained areas in 2003

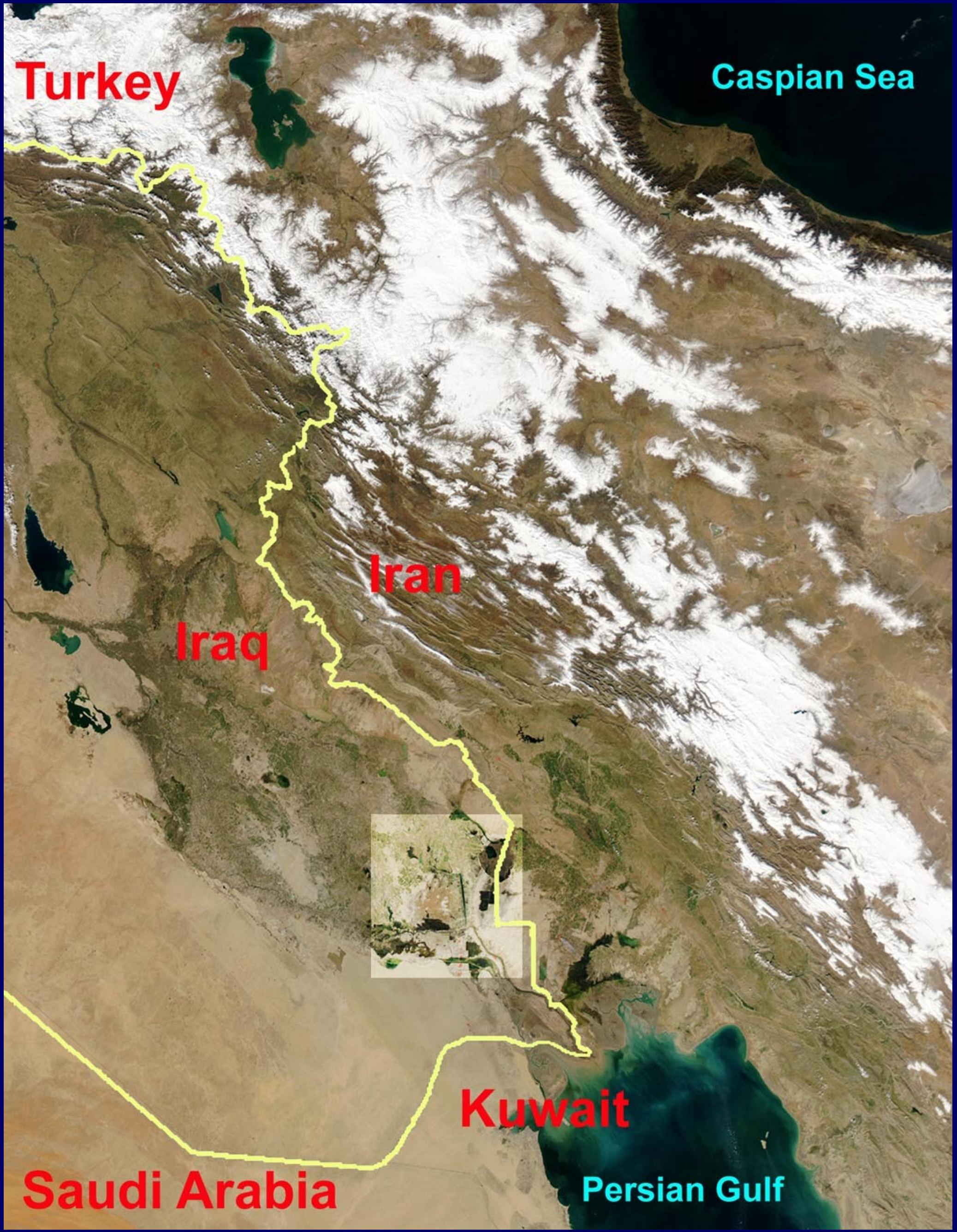
Hammar – remaining wetlands

Foto: Curtis Richardson


Hammar – drained areas

- **Tigris:**
  - **56% flow from Turkey**
  - **12% Iran**
  - **32% Iraq**
- **Euphrates:**
  - **88% flow from Turkey**
  - **9% Syria**
  - **3% Iraq**

NASA's Aqua Satellite
2/2004



- 2450 mm evaporation
- 100 mm precipitation

33in operation

22 planned or in construction

+ 18 dams in Iran

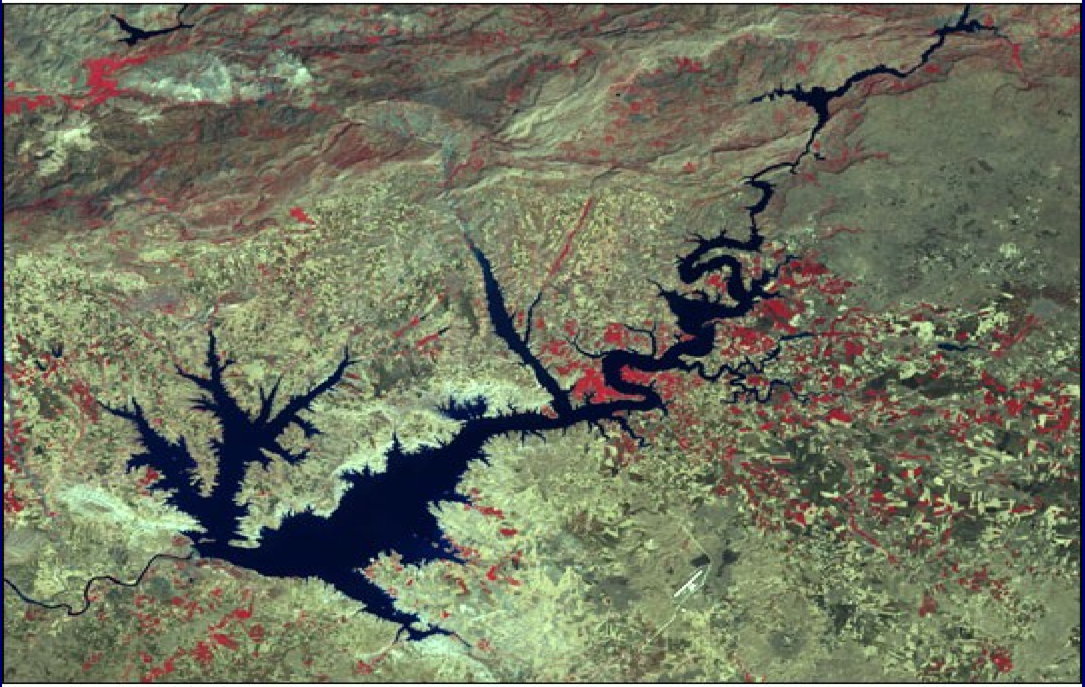
(Partow, 2001)

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

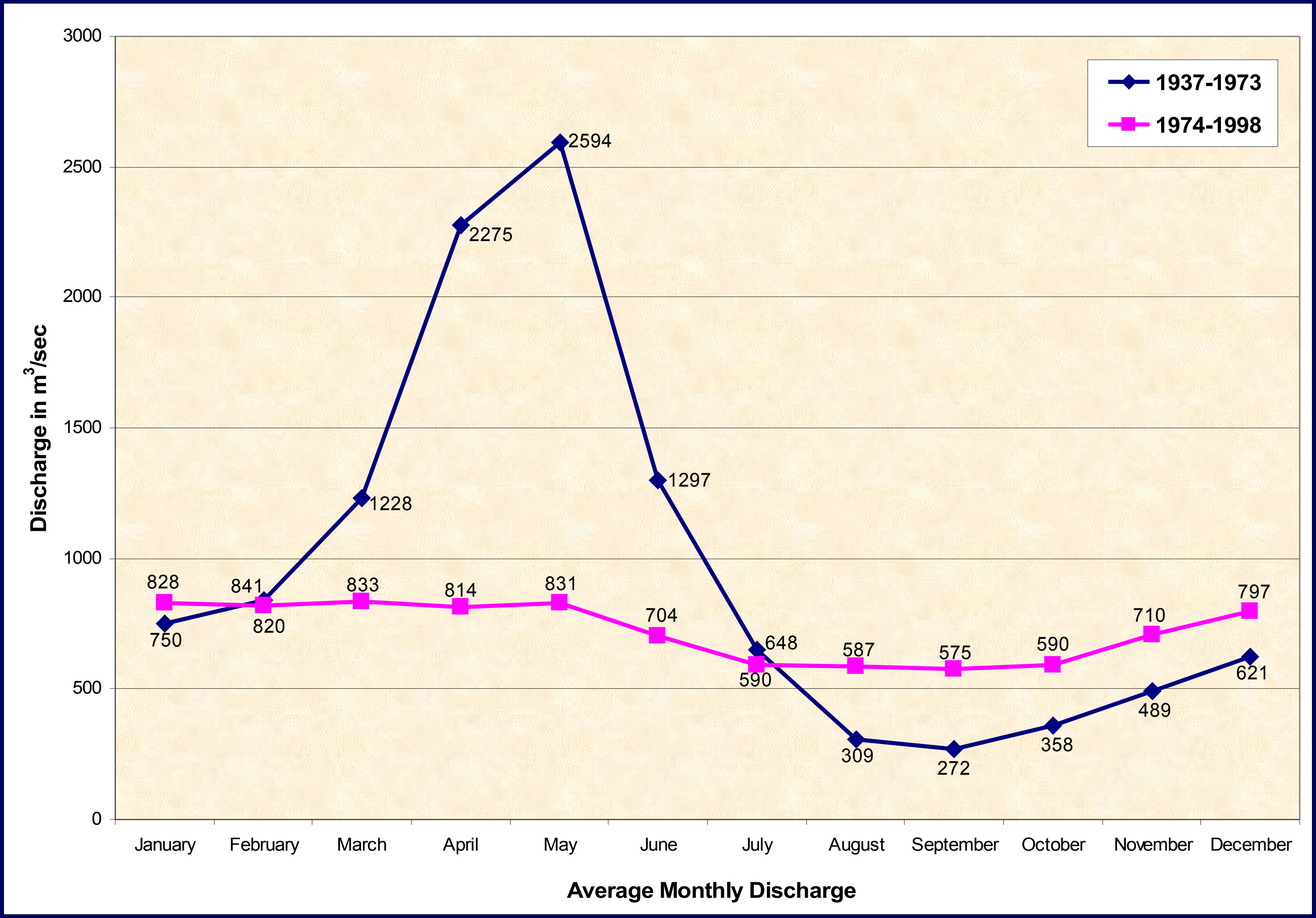
Created at UNEP/DEWA/GRID-Geneva; November 2000.

Atakürk dam

August 20, 1983

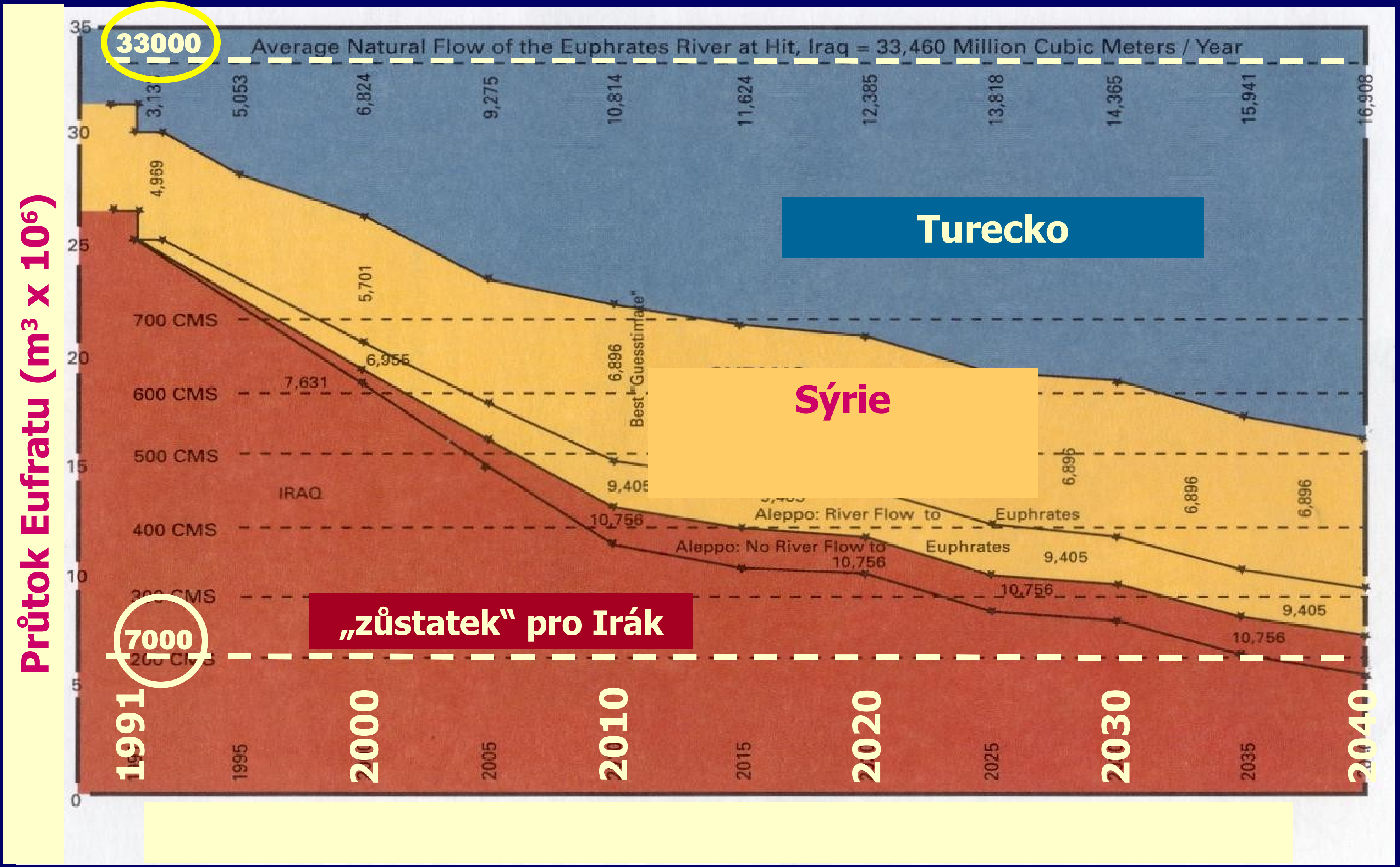


August 24, 2002



Eufrat flow at Hit-Husabia in Iraq during 1937-1973 (before dams construction) and during 1974-1998

Předpokládaný pokles průtoku Eufratu



Lorenz, 1999. (výpočty podle Kolars a Mitchell, 1991)

Tigris
IRAN
al-Gharraf
MOD
Amarah
Al Sanaf
D
al-Muminah
Euphrates
Central
Hawizeh
Hammar
KUWAIT


Sanaf-before flooding


Sanaf-partially flooded

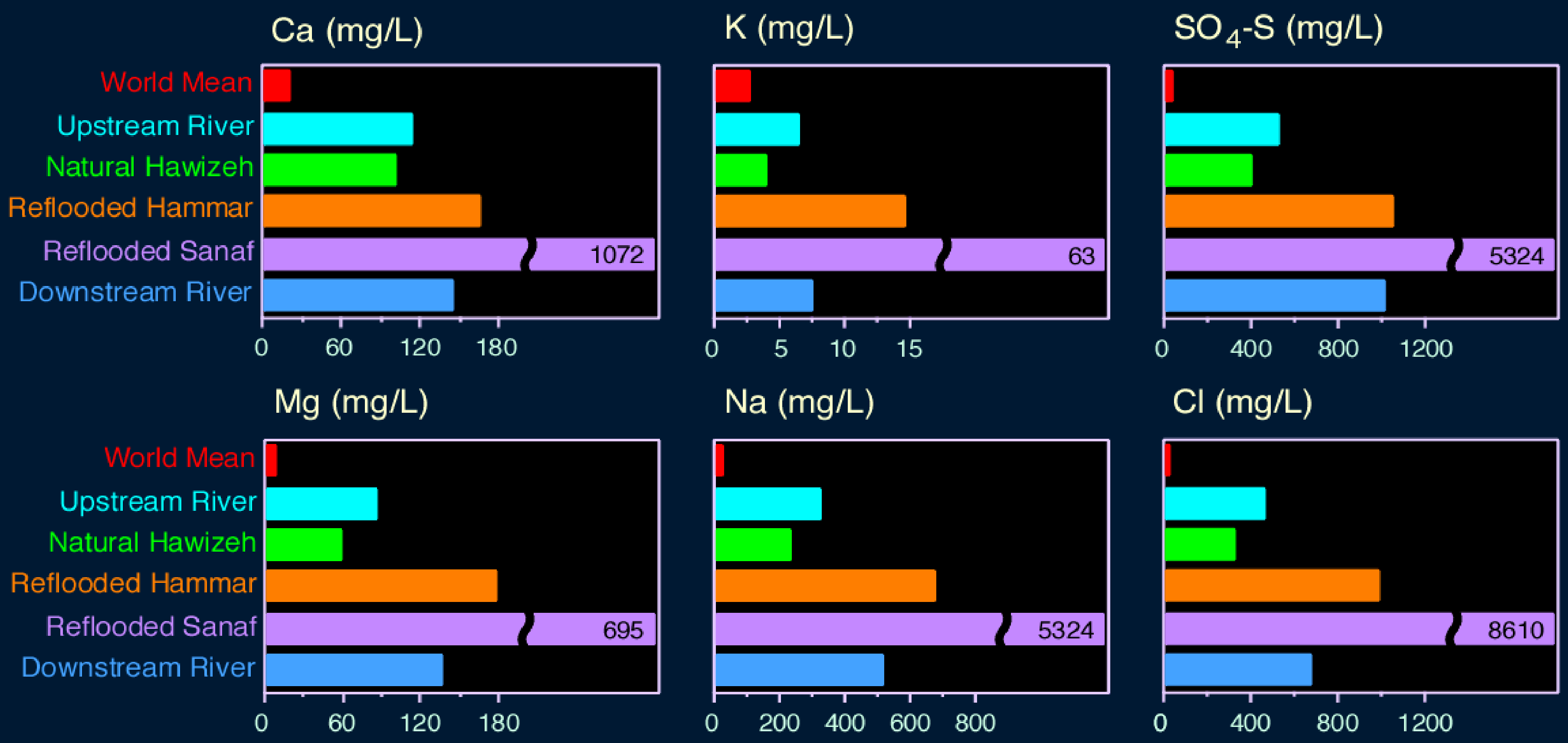

(Sanaf - 39% of the area flooded by September 2005)
Flooding ≠Restoration

	Flooded Hammar	Flooded Sanaf
Salinity (g/l)	0.96	17.49
Conductivity (mS/cm)	1.91	28.41
pH	7.95	9.40
Rozp. O_2 (mg/l)	7.03	8.79
RL (g/L)	1.24	18.46

Mediterranean Sea 38 g/l, Atlantic Ocean 36 g/l, Pacific Ocean 35 g/l, Indian Ocean 34 g/l, Baltic Sea 20 g/l

Richardson et al. (2005), Science 307

Selected chemical parameters for wetlands in southern Iraq



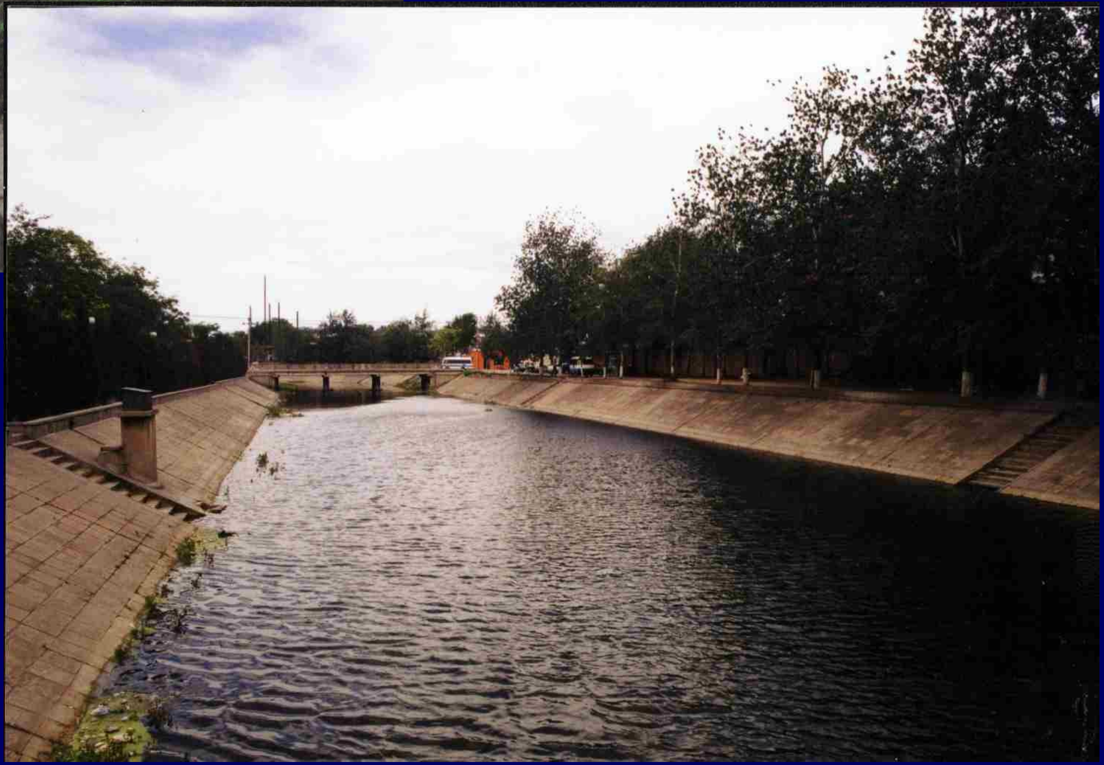
Richardson a Hussein, 2006

	Hammar	Al Sanaf	Mořská voda (průměr)
Sodium	700	5 330	10 500
Magnesium	170	700	1 350
Calcium	160	1 070	400
Potassium	15	63	380
Chloride	900	8 650	19 000
Sulfate	1 000	5 330	2 710

Lake shore wetlands were destroyed with a dam construction at Dianchi Lake

Riverside Wetland Loss

Upstream



Downstream

Results of Wetland Degradation

- That causes increased nutrient loss to water
- Lake eutrophication
- Bank erosion
- Flood
- Biodiversity loss
- Etc.


Thank you for your attention