LIMNOLOGÍA 2023

Docentes: M.Sc. Maite Burwood, Lic. Claudia Fosalba, Lic. Lucía González-Madina, Dr. Guillermo Goyenola, Lic. Paula Levrini y Dr. Néstor Mazzeo

CURE Centro Universitario Regional del Este
UNIVERSIDAD DE LA REPÚBLICA URUGUAY

RESERVORIOS

(con foco en grandes embalses)

A° San Francisco, Minas

Represa, embalse / Pantano (España)
Reservoir, dam, impoundment
RESERVORIOS

Cuerpos de agua construidos o modificados por la actividad humana para propósitos específicos, con el objetivo de proveer un recurso seguro y controlable.

Principales usos:

- Suministro de agua para potabilización
- Suministro para la actividad industrial (enfriamiento, etc.)
- Generación hidroeléctrica
- Riego, cría de ganado
- Regulación de cursos de agua y control de inundaciones
- Recreación, actividades náuticas y otros usos recreacionales
- Disposición de residuos
- Pesquerías comerciales y recreacionales
- Navegación

¡$!

¿UY?

Thornton, J., A. Steel & W. Rast, 1996. Chapter 8. Reservoirs. In Chapman, D. (ed) Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring. 2nd. UNESCO/WHO/UNEP. http://www.who.int/water_sanitation_health/resourcesquality/wqachapter8.pdf

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OSE, Aguas Corrientes


OSE, Paso Severino


OSE, Paso Severino


Embalse de Paso Severino, Florida
www.uruguaydesdeloalto.com
2021


www.uruguaydesdeloalto.com
2023
www.stonek.com


Embalse del arroyo Canelón Grande - Ruta 5
www.UruguayDesdeLoAlto.com
2015
www.stonek.com


www.UruguayDesdeLoAlto.com
2023
www.stonek.com

Laguna del Sauce

http://www.panoramio.com/photo/41342730?source=wapi&referrer=kh.google.com

San Francisco (Minas)

2023

Represa de Cuñapirú (1882)

Salto Grande

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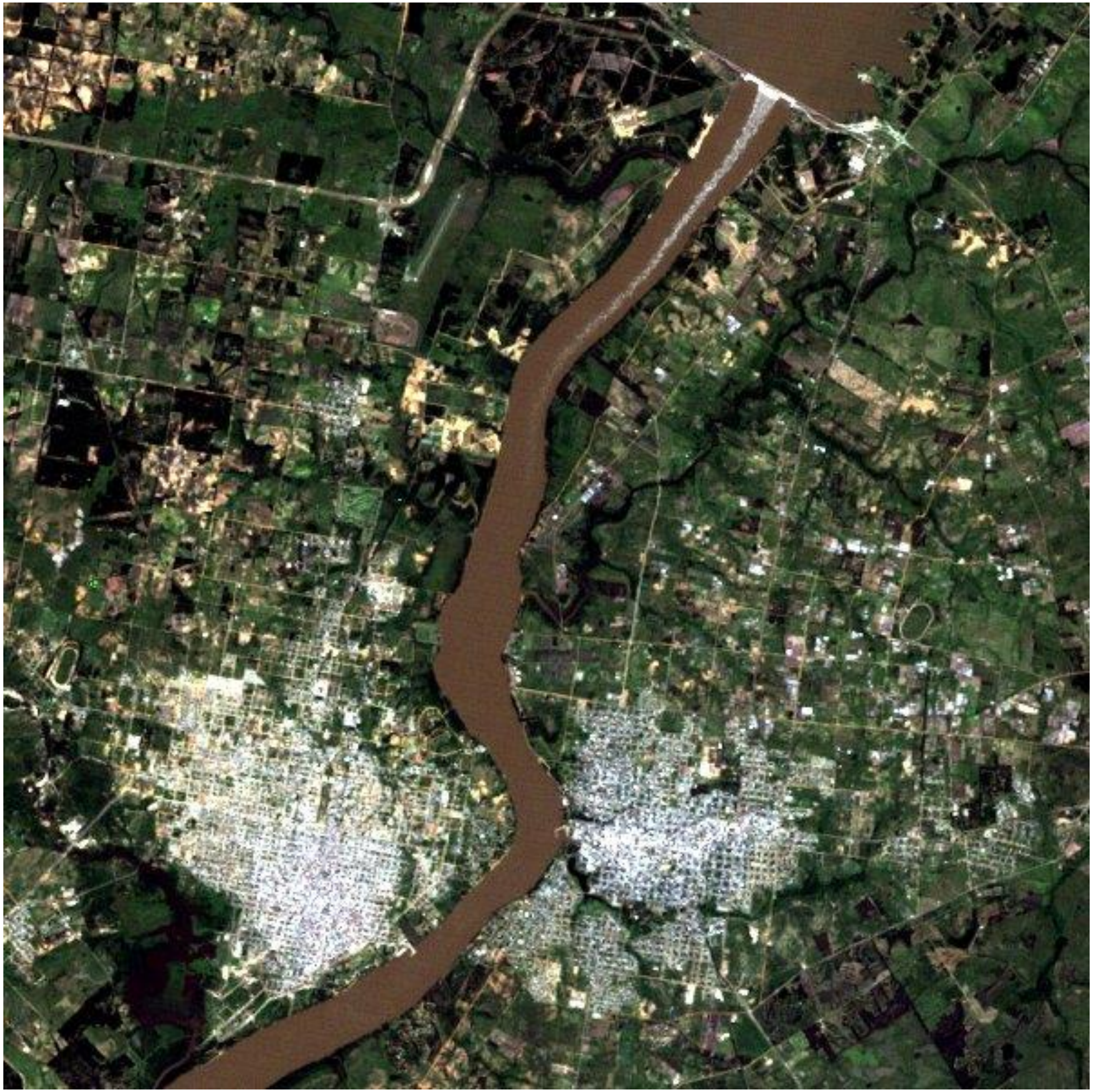

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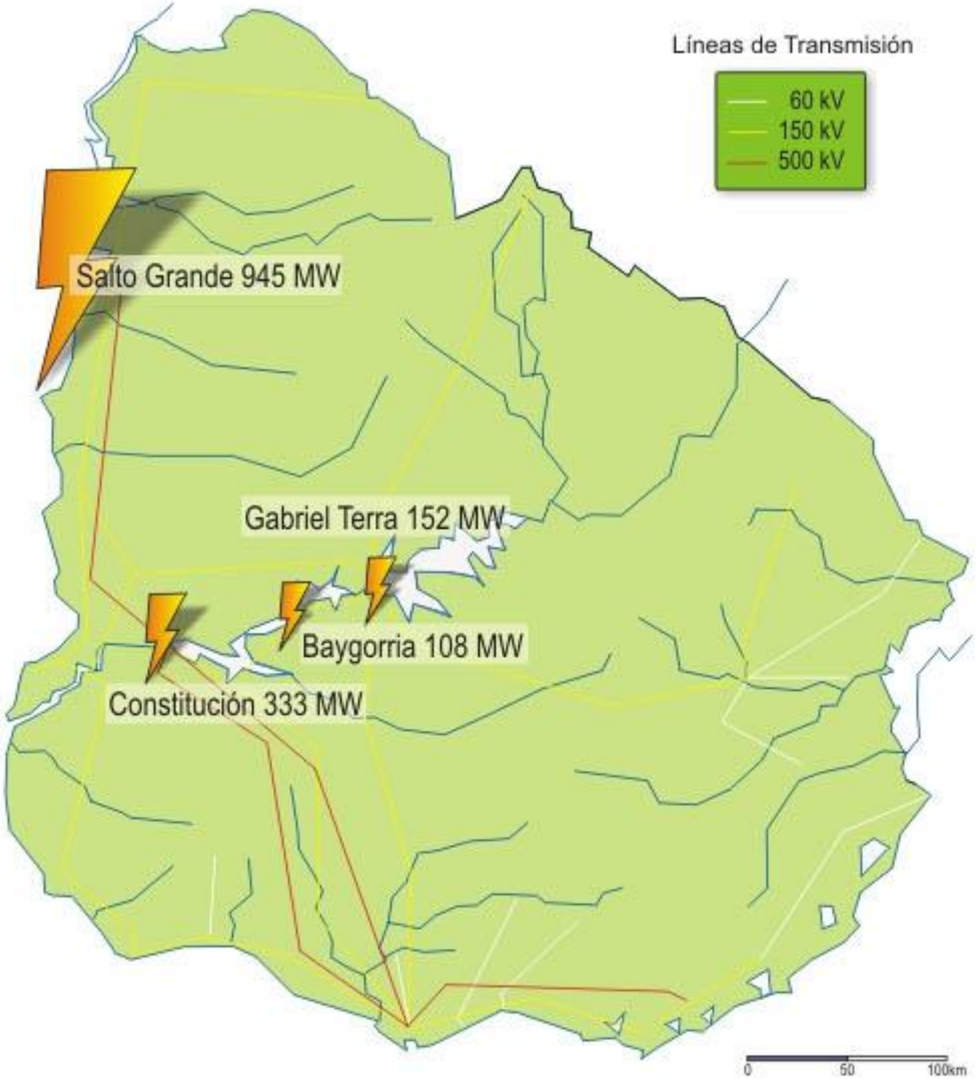

Centrales Hidroeléctricas

Capacidad Instalada y Líneas de Transmisión

Fuentes: Achkar (2000) y UTE

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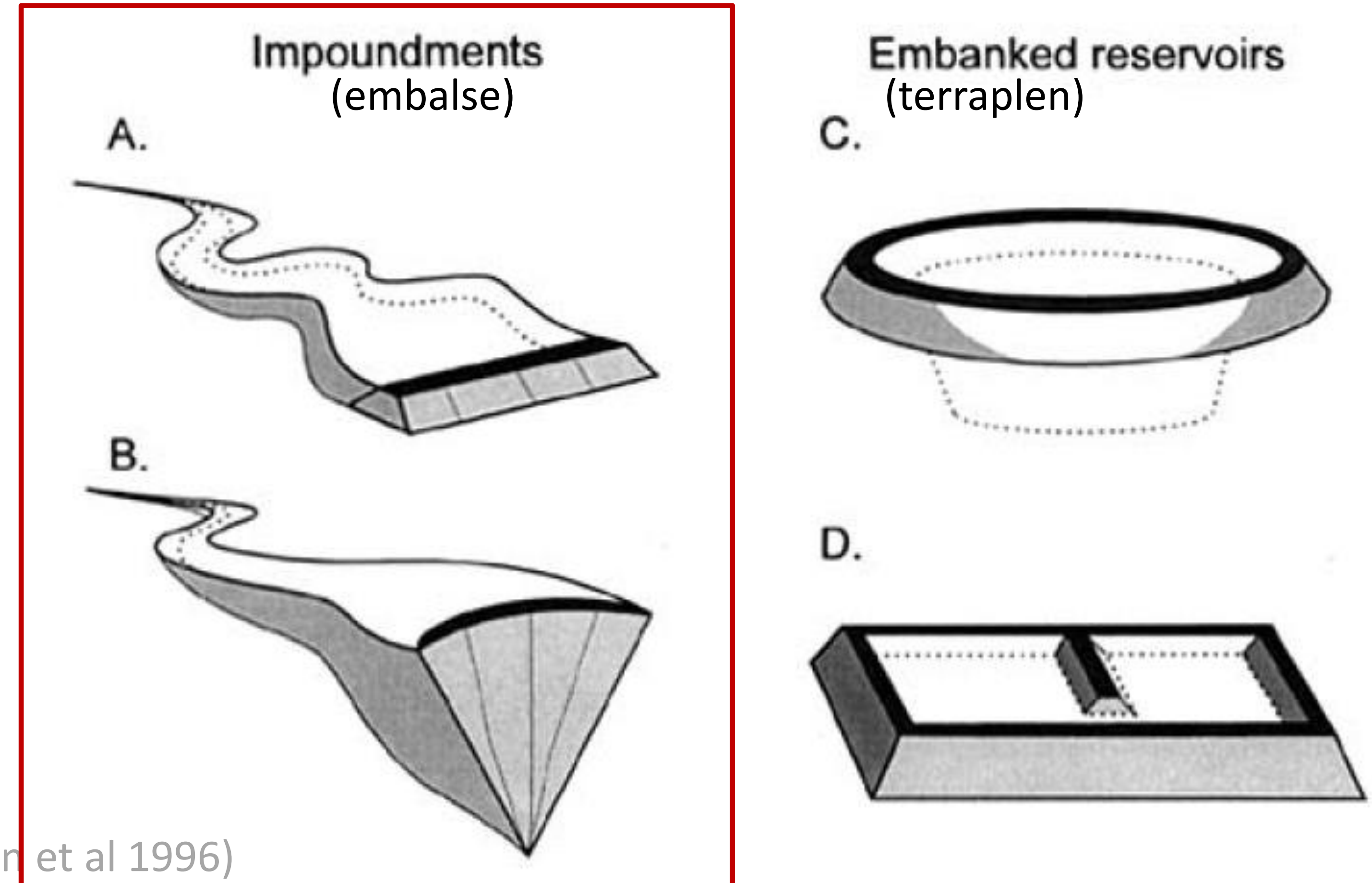
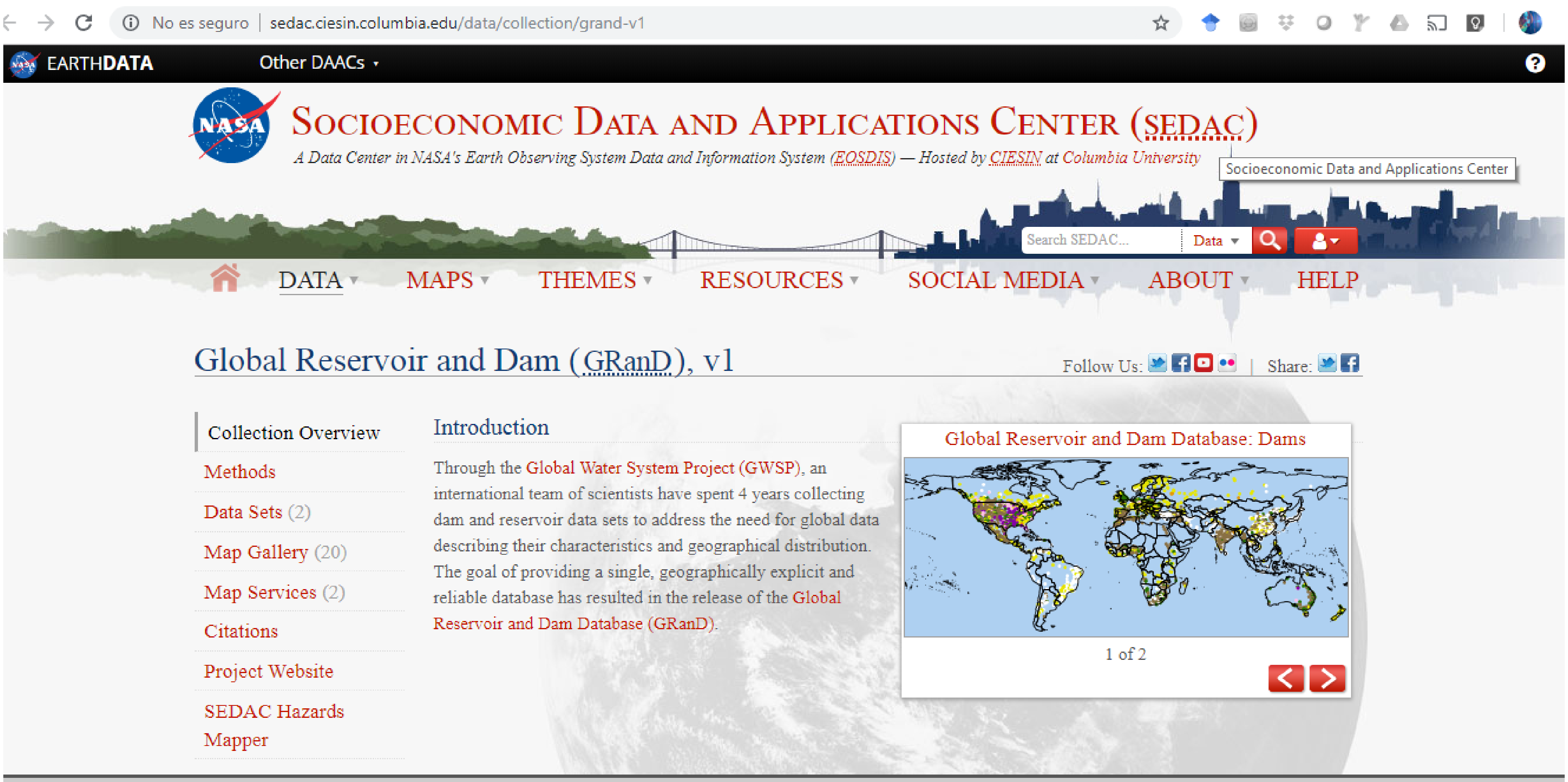
Represa, embalse / Pantano (España)
Reservoir, dam, impoundment
RESERVORIOS

Figure 8.3 Examples of the principal reservoir configurations: A. shallow, 'U' shaped; B. deep, 'V' shaped; C. deep, regular; D. shallow, regular

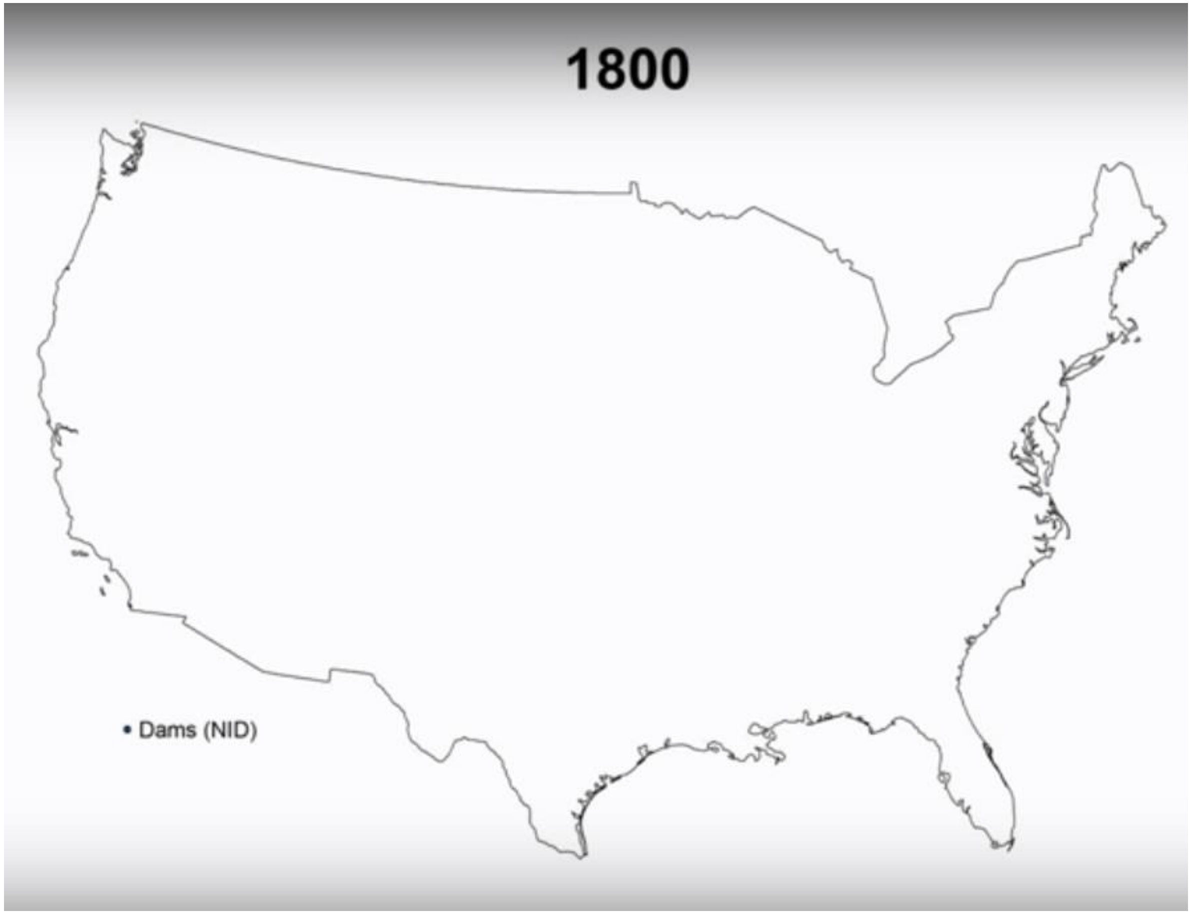


(Thornton et al 1996)



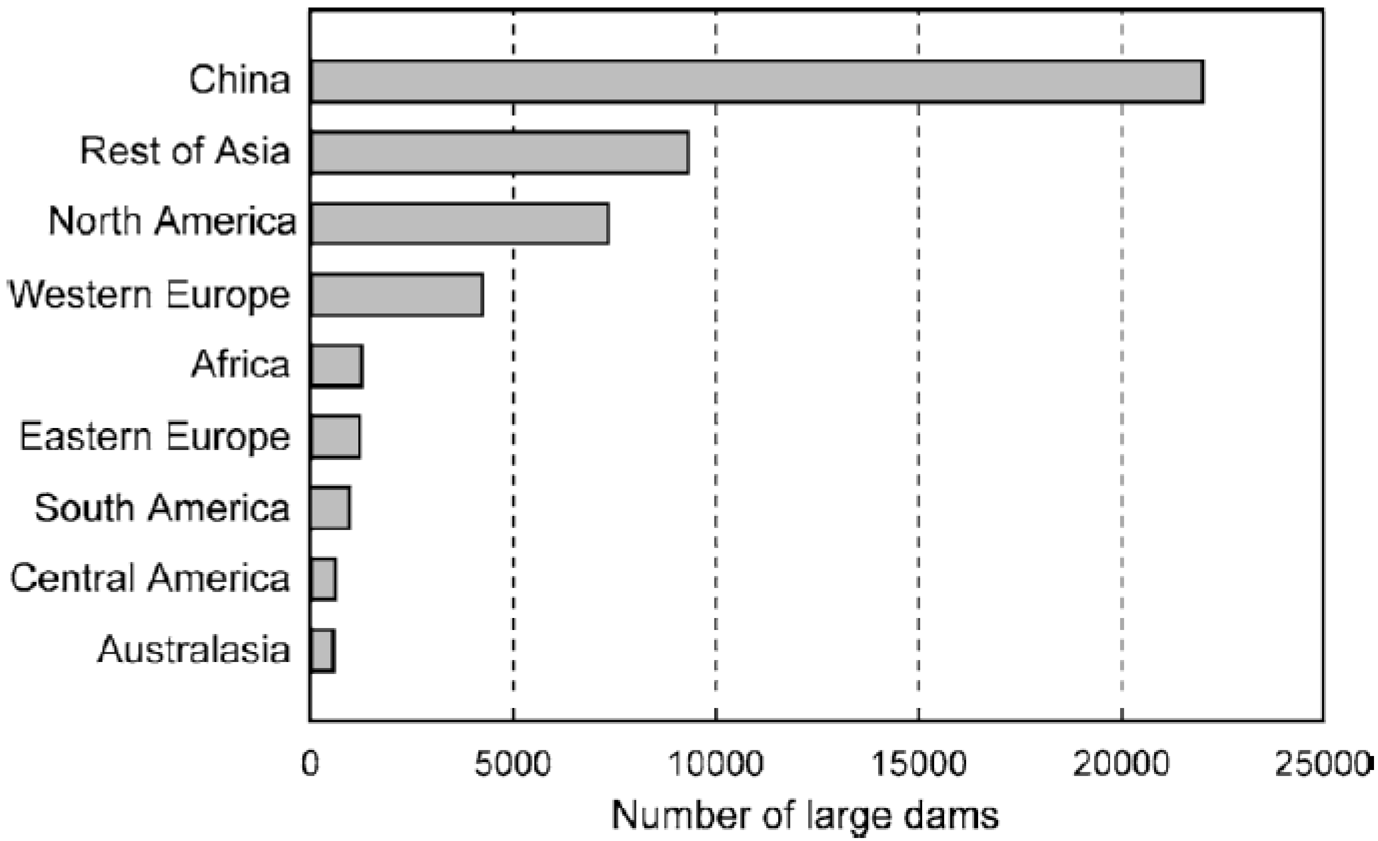
World dams since 1800

http://www.youtube.com/watch?v=OR5IFcSsaxY#t=12



Reservoir emplacement in the USA since 1800
https://csdms.colorado.edu/wiki/Movie:US_dams

http://www.youtube.com/watch?v=RPm9LUZDCgg



25 % de toda el agua que fluía a los océanos había sido previamente embalsada (UNEP, 1991).

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Fragmentation and Flow Regulation of the World's Large River Systems

Christer Nilsson,[1*†] Catherine A. Reidy,[1*] Mats Dynesius,[1] Carmen Revenga[2]

A global overview of dam-based impacts on large river systems shows that over half (172 out of 292) are affected by dams, including the eight most biogeographically diverse. Dam-impacted catchments experience higher irrigation pressure and about 25 times more economic activity per unit of water than do unaffected catchments. In view of projected changes in climate and water resource use, these findings can be used to identify ecological risks associated with further impacts on large river systems.

Humans have extensively altered river systems through impoundments and diversions to meet their water, energy, and transportation needs. Today, there are >45,000 dams above 15 m high, capable of holding back >6500 km^3 of water (*1*), or about 15% of the total annual river runoff globally (*2*). Over 300 dams are defined as giant dams, which meet one of three criteria on height (>150 m), dam volume (>15 million m^3), or reservoir storage (>25 km^3) (*3*). The recently constructed Three Gorges Dam on the Chang Jiang (Yangtze) in China is the largest, 181 m high and with a reservoir storing >39 km^3 (*4*, *5*). Although statistics summarizing the world's large dams are available (*3*, *4*, *6*, *7*), detailed multiscale data have not been synthesized globally.

Catchment-scale impacts of dams on ecosystems are generally well known, with both upstream and downstream effects stemming from inundation, flow manipulation, and fragmentation (*8*–*10*). Inundation destroys terrestrial ecosystems and eliminates turbulent reaches, disfavoring lotic biota. It can cause anoxia, greenhouse gas emission, sedimentation, and an upsurge of nutrient release in new reservoirs (*6*, *11*, *12*). Resettlement associated with inundation can result in adverse human health effects and substantial changes in land use patterns (*13*, *14*). Flow manipulations hinder channel development, drain floodplain wetlands, reduce floodplain productivity, decrease dynamism of deltas, and may cause extensive modification of aquatic communities (*15*–*18*). Dams obstruct the dispersal and migration of organisms, and these and other effects have been directly linked to loss of populations and entire species of freshwater fish (*19*–*21*). The World Commission on Dams produced the most comprehensive review of dam impacts yet (*22*), with illustrative catchment-scale case studies. However, data were not available for a global analysis based on subcatchment-scale resolution, integrating hydrologic, ecological, and socioeconomic data. Such a synthesis is needed to understand the multiple spatial, temporal, and interactive impacts of dams.

Here, we present a global overview of flow regulation and channel fragmentation in the world's largest river systems, which comprise a total virgin mean annual discharge (VMAD, the discharge before any substantial human manipulations) of some 790,000 $m^3 s^{-1}$, or 60% of the world's river runoff. We proceeded by (i) identifying 153 large river systems (LRSs) in Latin America, Africa, Asia, and Australasia that we had not previously assessed (*23*), (ii) locating and gathering storage capacity data for their dams, (iii) quantifying channel fragmentation by dams, (iv) and quantifying flow regulation by relating storage capacity to discharge. We also updated these same data for 139 systems that we had previously assessed in the Northern Hemisphere (*23*), combined the two data sets for a total of 292 river systems, and, on the basis of these data, classified the river systems as either unaffected, moderately affected, or strongly affected (*24*). We were unable to assess rivers in most of Indonesia and a small part of Malaysia (because of a lack of reliable discharge data). We included irrigation data for all 292 LRSs and analyzed global distribution of impact relative to terrestrial biomes and economic activity.

We defined an LRS as a system that has, anywhere in its catchment, a river channel section with a VMAD of ≥350 $m^3 s^{-1}$ (*23*, *25*). By river system, we mean entire networks of stream and river channels interconnected by surface freshwater, from the headwaters to the sea (*26*). The 292 LRSs (table S1 and Fig. 1) drain 54% of the world's land area. North and Central America contain more LRSs (88 total) than any other continent, but on average these systems contribute less water and have smaller catchment areas than do those of Asia, Africa, and South America. Of the 10 LRSs with highest discharge, 6 lie in Asia, 2 in South America, 1 in Africa, and 1 in North and Central America.

The catchments of LRSs encompass at least some part of all 16 of the world's nonmarine biomes as classified by Olson *et al.* (*27*) and >50% of 11 of these biomes, including 87% of all boreal forests and 83% of all flooded grasslands and savannahs. The biomes with least proportion of their surface area in LRSs are rock and ice (1%); mangroves (17%); and Mediterranean forests, woodlands, and scrub (19%). In all, 72 LRSs span only one biome, whereas the Ganges-Brahmaputra system (AS-65) encompasses the widest diversity (10 biomes), followed by the Amazonas-Orinoco (SA-11; these rivers have a natural cross-channel), Amur (AS-20), Yenisei (AS-5), Zambezi (AF-6), and Indus (AS-73) systems, each spanning eight.

Nearly half (139) of all LRSs (48%) remain unfragmented (*28*) by dams in the main channel, 119 systems (41%) have unfragmented tributaries, and 102 systems (35%) are completely unfragmented. Europe contains the smallest number of completely unfragmented LRSs (just three rivers in northwestern Russia). The continent with the greatest number (35) of unfragmented LRSs is North and Central America, and the greatest proportion is in Australasia (74%). Twelve LRSs (9 in Europe and 3 in the United States) have <25% of the main channel's length left unfragmented.

The greatest flow regulation (*29*) was for the Volta river system in Africa (AF-19, 428%). In North and Central America, both the Manicougan (NA-35) and Colorado (NA-70) systems are regulated >250%, and in South America the most highly regulated system is the Rio Negro in Argentina (SA-22, 140%). The most highly regulated systems in Asia are the Shatt Al Arab (or Euphrates-Tigris) in the Middle East (AS-74, 124%) and the Mae Khlong in Thailand (AS-58, 130%). Flow regulation does not exceed 100% in any LRS in Europe or Australasia. A flow regulation of 100% indicates that the entire discharge of one year could be held back and released by the dams in the river system.

The numbers of unaffected and strongly affected LRSs are roughly equal (120 and 104, respectively), whereas moderately affected systems represent just 23%, or 68 of the 292 LRSs (Fig. 1). Of the 10 LRSs with highest discharge, 6 are moderately affected and 4 are strongly affected. The world's two largest discharges, the Amazonas-Orinoco and Congo, are moderately affected, and the third largest discharge, the Chang Jiang, is strongly affected (table S1). The largest unaffected LRS is the

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*These authors contributed equally to this work.
†To whom correspondence should be addressed. E-mail: christer.nilsson@emg.umu.se

(Nilsson et al. 2005)

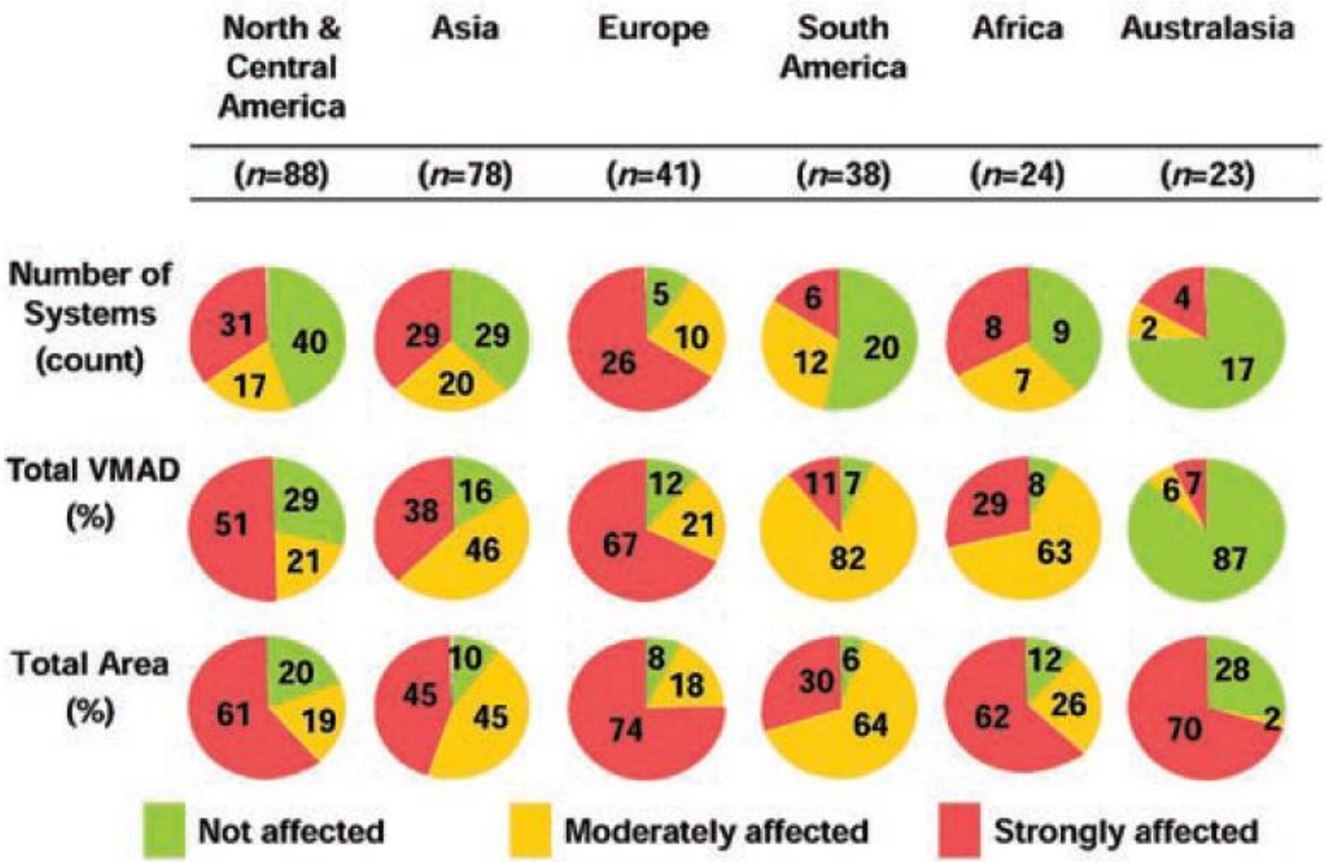
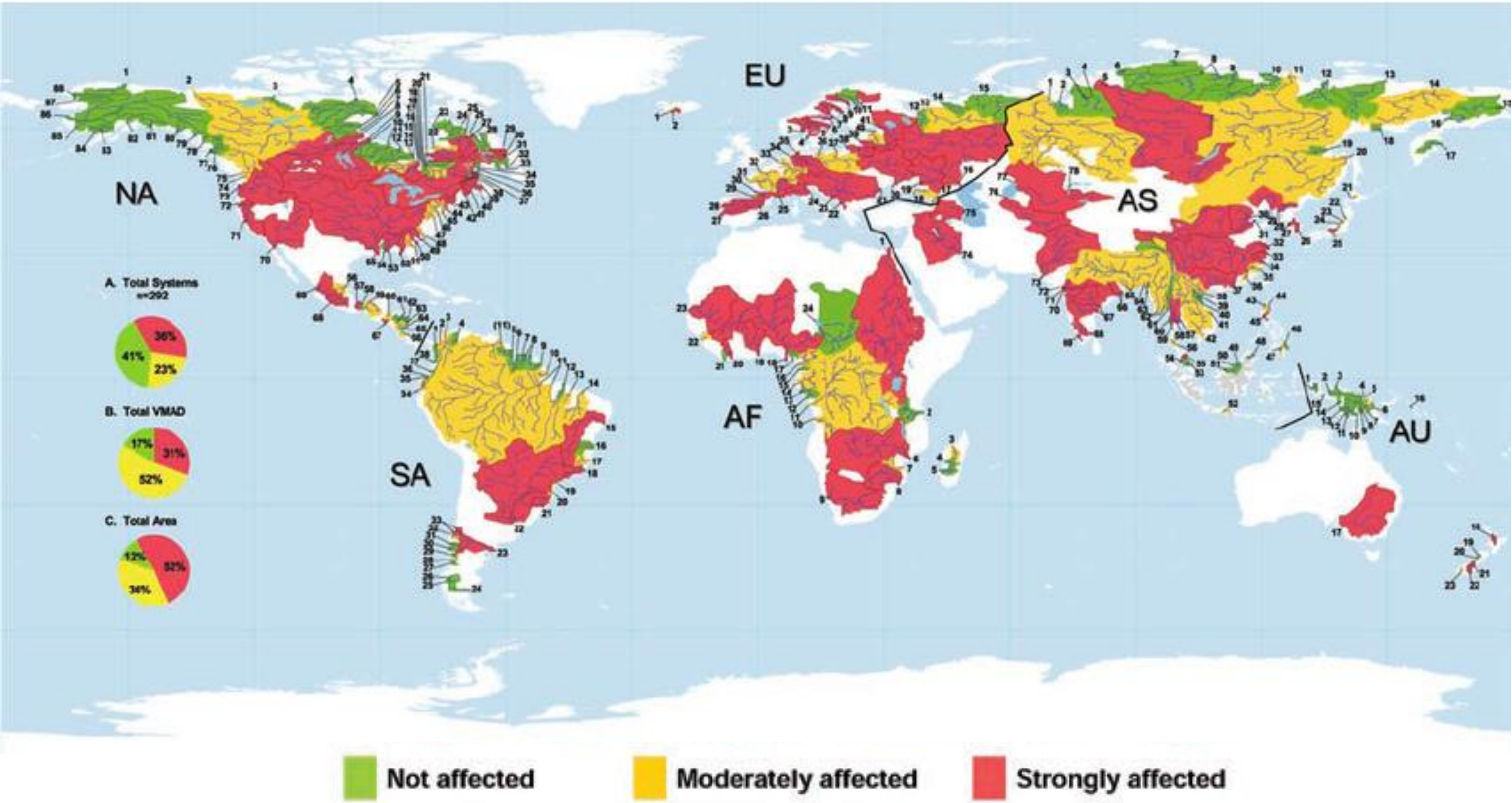


Fig. 2. Total number of systems, total water discharge, and total basin area of strongly affected, moderately affected, or unaffected within each continent's LRSs. Percentages may not total 100% because of independent rounding.

VMAD: total virgin mean annual discharge
LRS: large rivers systems

(Nilsson et al. 2005)



Clasificación de impacto basada en la fragmentación del canal y la regulación del flujo por embalses para los 292 grandes ríos.

(Nilsson et al. 2005)

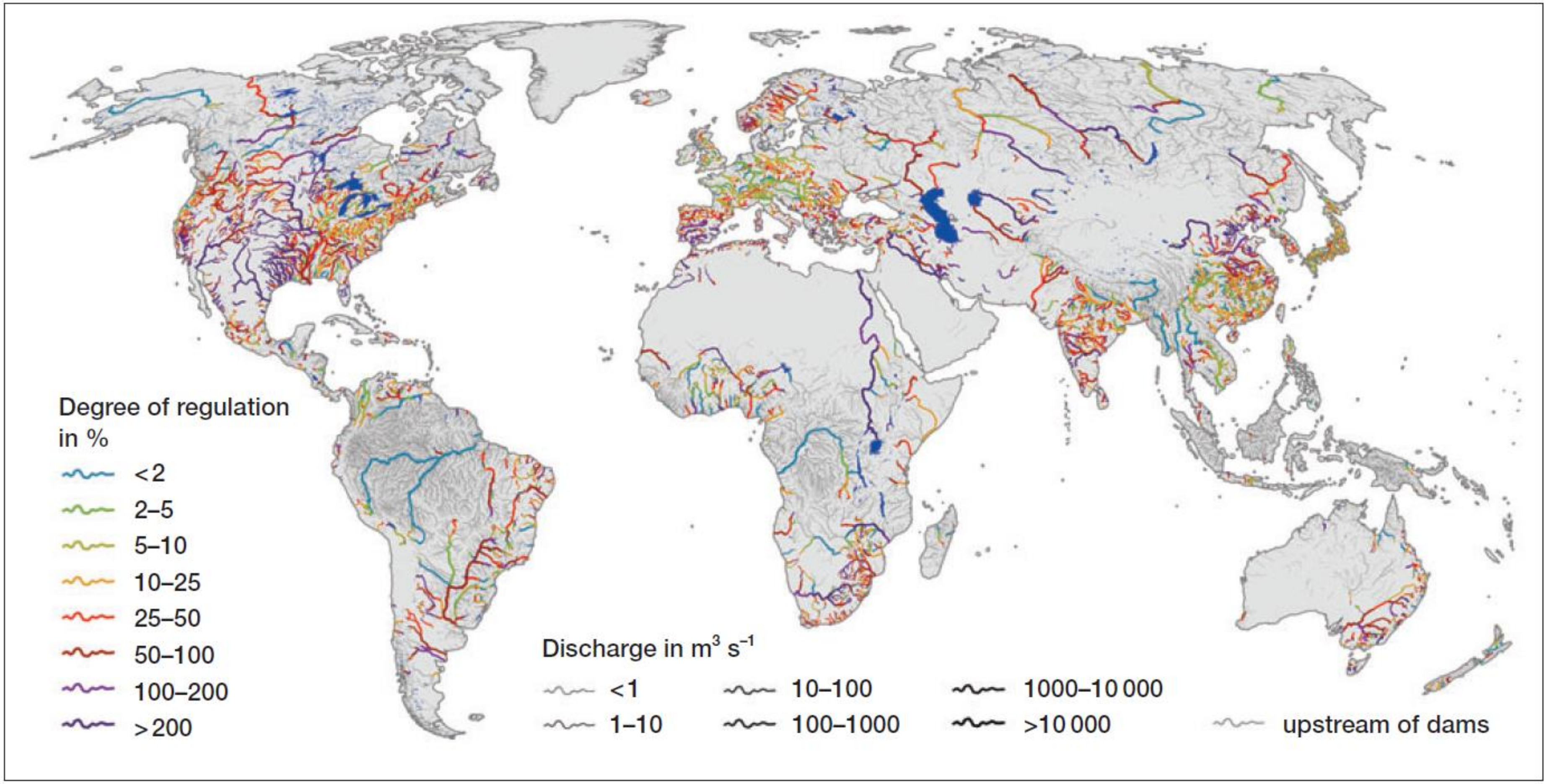


Figure 2. *Affected river reaches downstream of GRanD reservoirs. Different colors show an increasing degree of regulation, whereas line width is proportional to average long-term discharge. Rivers in gray have no large dams upstream.*

Front Ecol Environ 2011; 9(9): 494–502, doi:10.1890/100125

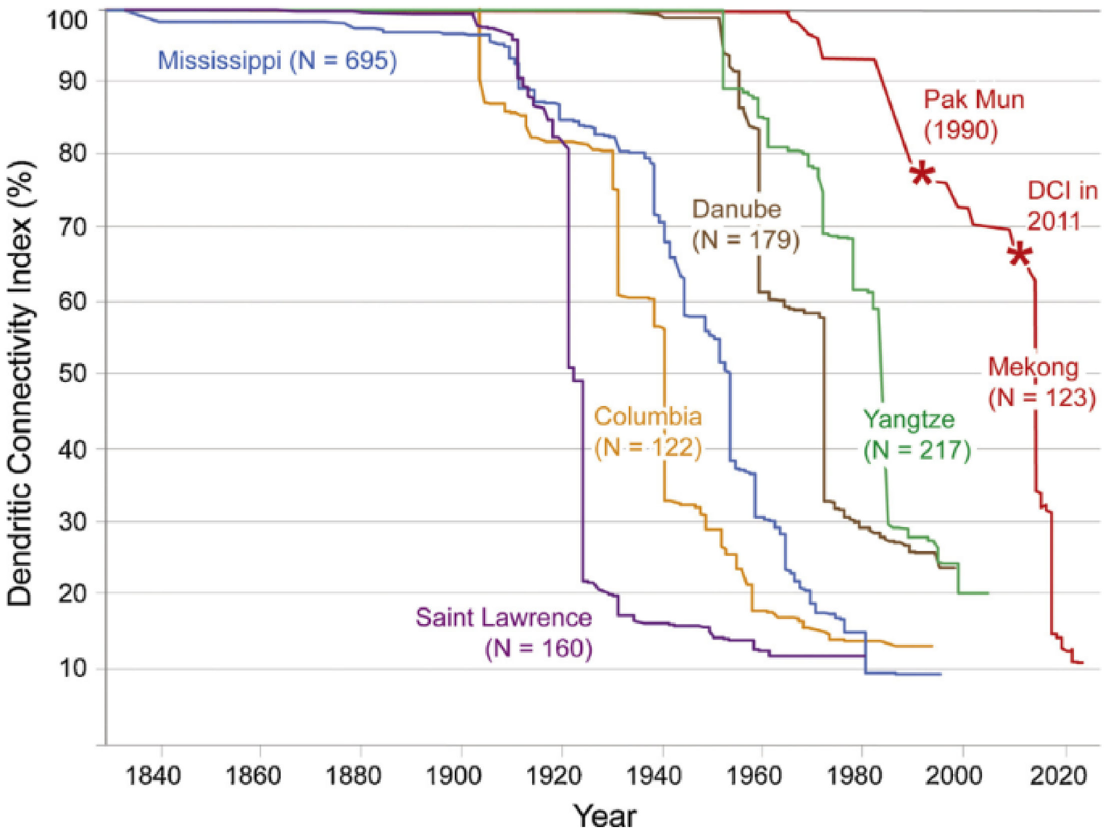


Fig. 5. Fragmentation history for selected large river basins. As there are currently no consistent river habitat classification or migration range maps available on a global scale (a prerequisite for the calculation of RCI_{CLASS} or RCI_{RANGE}), we calculated only the original DCI (Cote et al., 2009) in this assessment. The DCI decreases over time as dams are built in the river network. For the MRB, historic dam constructions prior to 2011 are based on a combination of the GRanD and MRC databases (Lehner et al., 2011; MRC, 2009), while future connectivity is based on a list of proposed dams with commission dates (MRC, 2009). Connectivity decreases rapidly until 2022 if dam development proceeds as planned. *N* represents the total number of investigated dams in the basin.

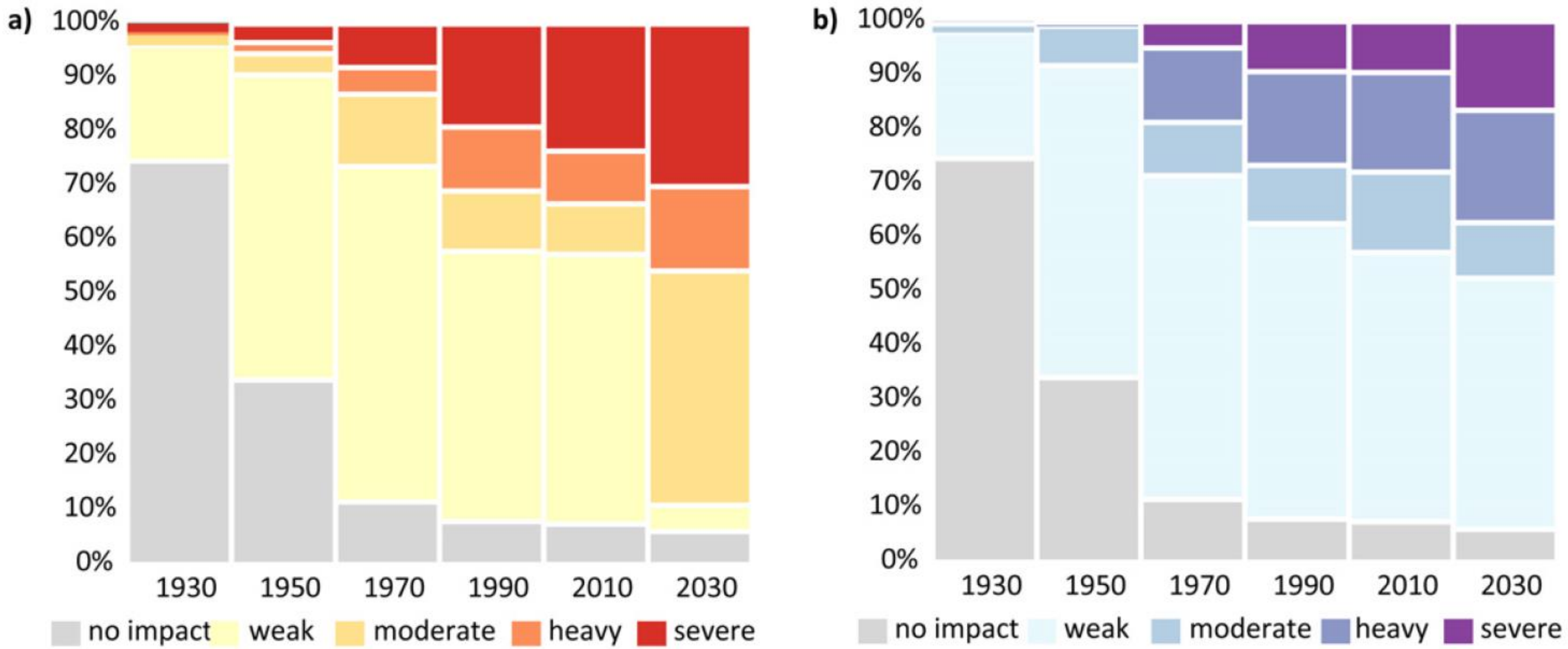


Figure 4. Proportion of global river volume impacted by fragmentation (a) and flow regulation (b) for each impact category (see figure 6 for classification criteria). See table S2 for impact values summarized by affected length (km) instead of volume.

Environmental Research Letters

LETTER

An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales

Günther Grill[1], Bernhard Lehner[1], Alexander E Lumsdon[2,3], Graham K MacDonald[4], Christiane Zarfl[2,6] and Catherine Reidy Liermann[5]

Günther Grill et al 2015 Environ. Res. Lett. 10 015001
DOI 10.1088/1748-9326/10/1/015001

Three Gorges; Yangtze River, China
2008
110 metros de altura
18.000/33.000 millones de dólares

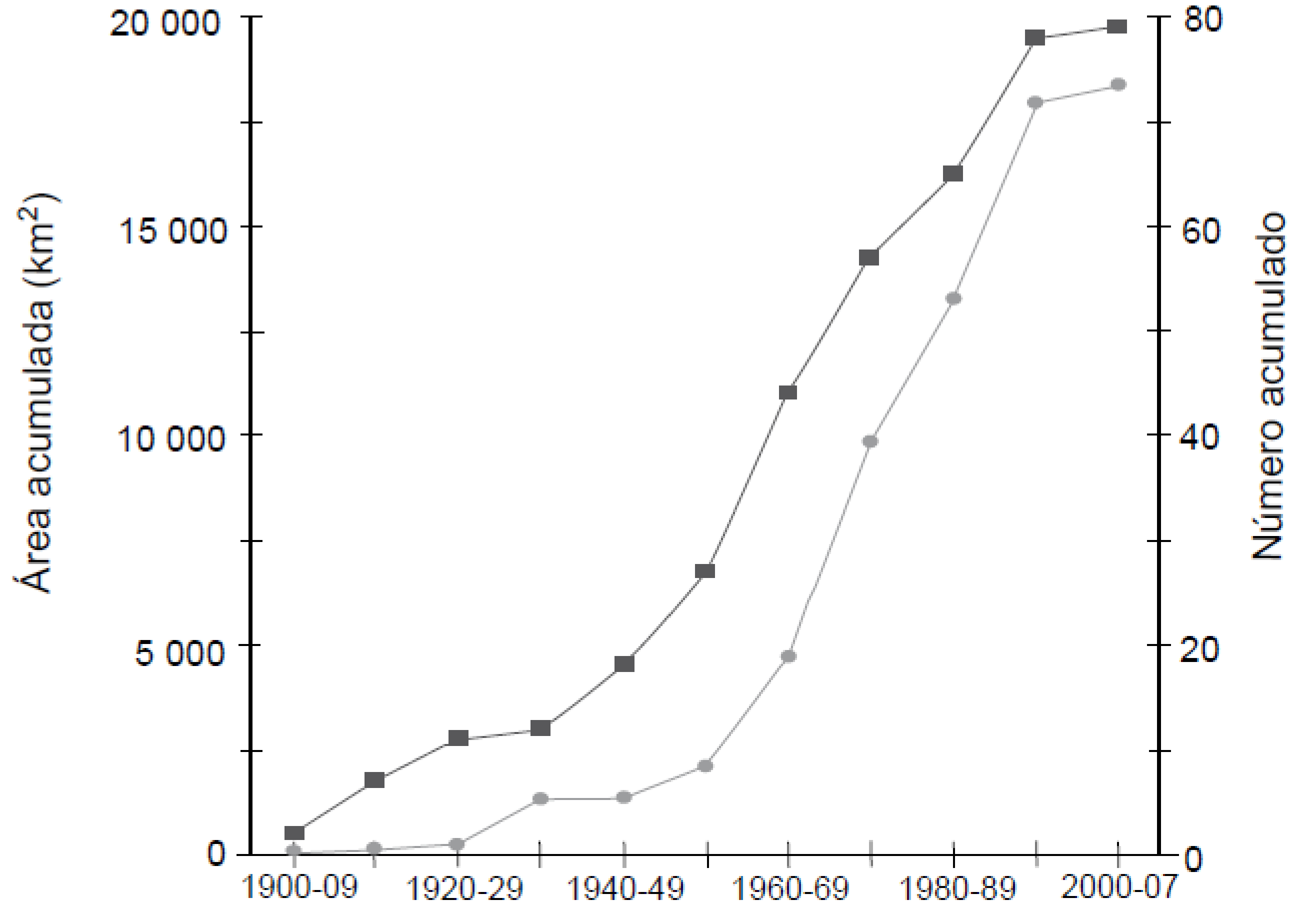


Figura 16.1. Área cubierta por los embalses(■) y número de represas (●) construidas en Brasil (adaptado de Agostinho *et al.*, 2007a).

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http://www.faunagua.org/biblioteca/3Cap16.pdf

Figure 1 – Distribution of the main hydroelectric power plants in Brazil. Notice the concentration in the South and Southeast regions (Kelman et al., 2006).

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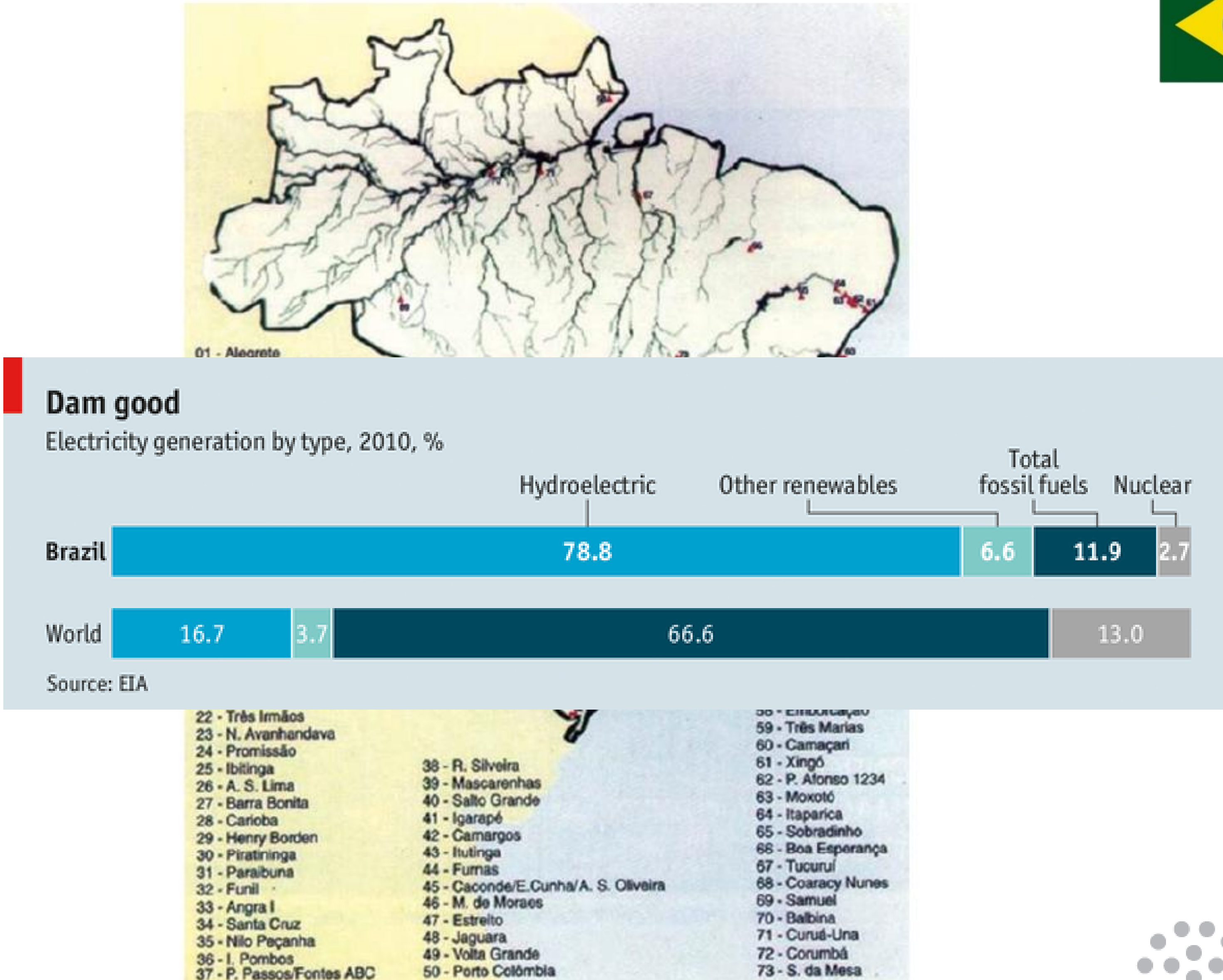

Figure 1 – Distribution of the main hydroelectric power plants in Brazil. Notice the concentration in the South and Southeast regions (Kelman et al., 2006).

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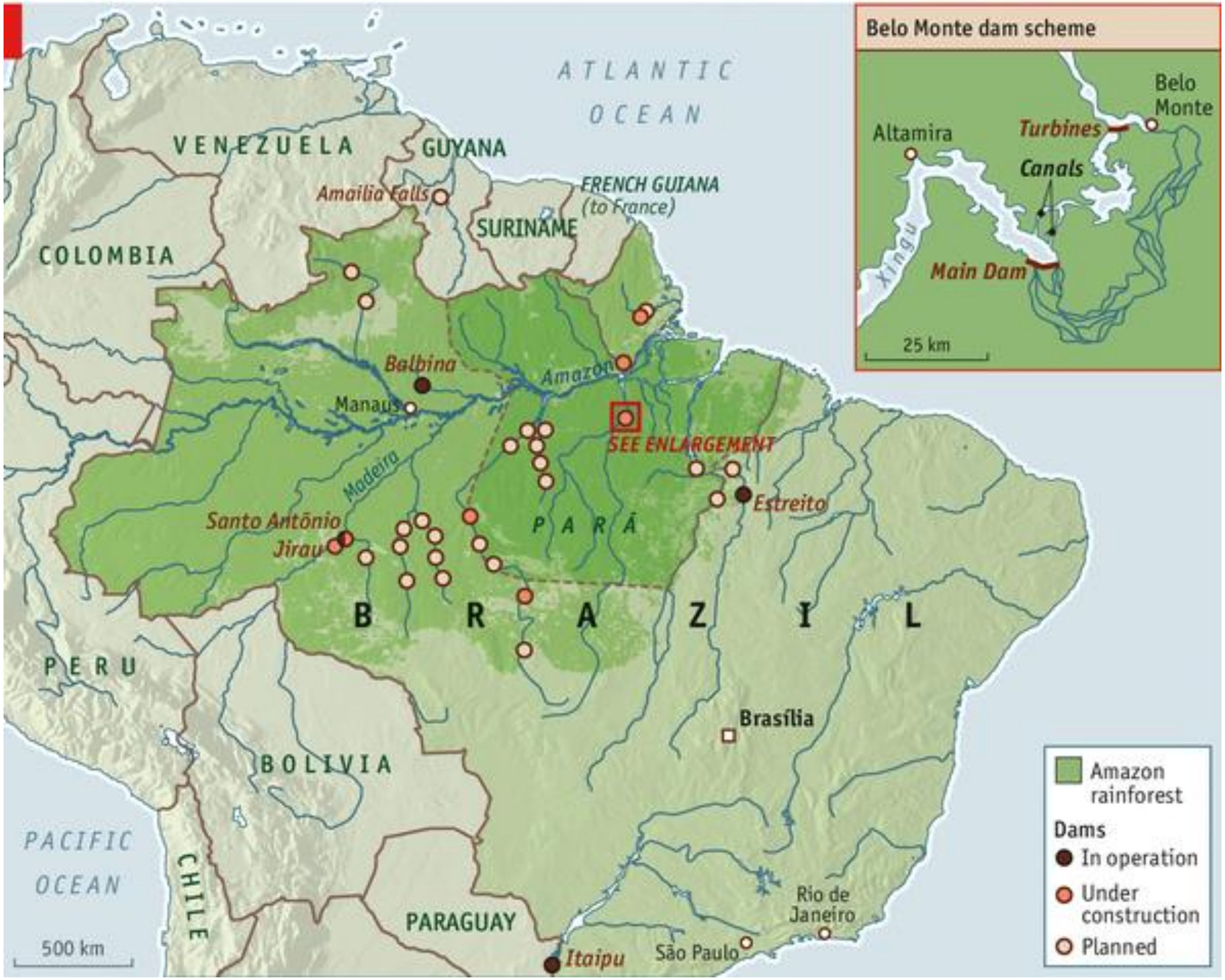


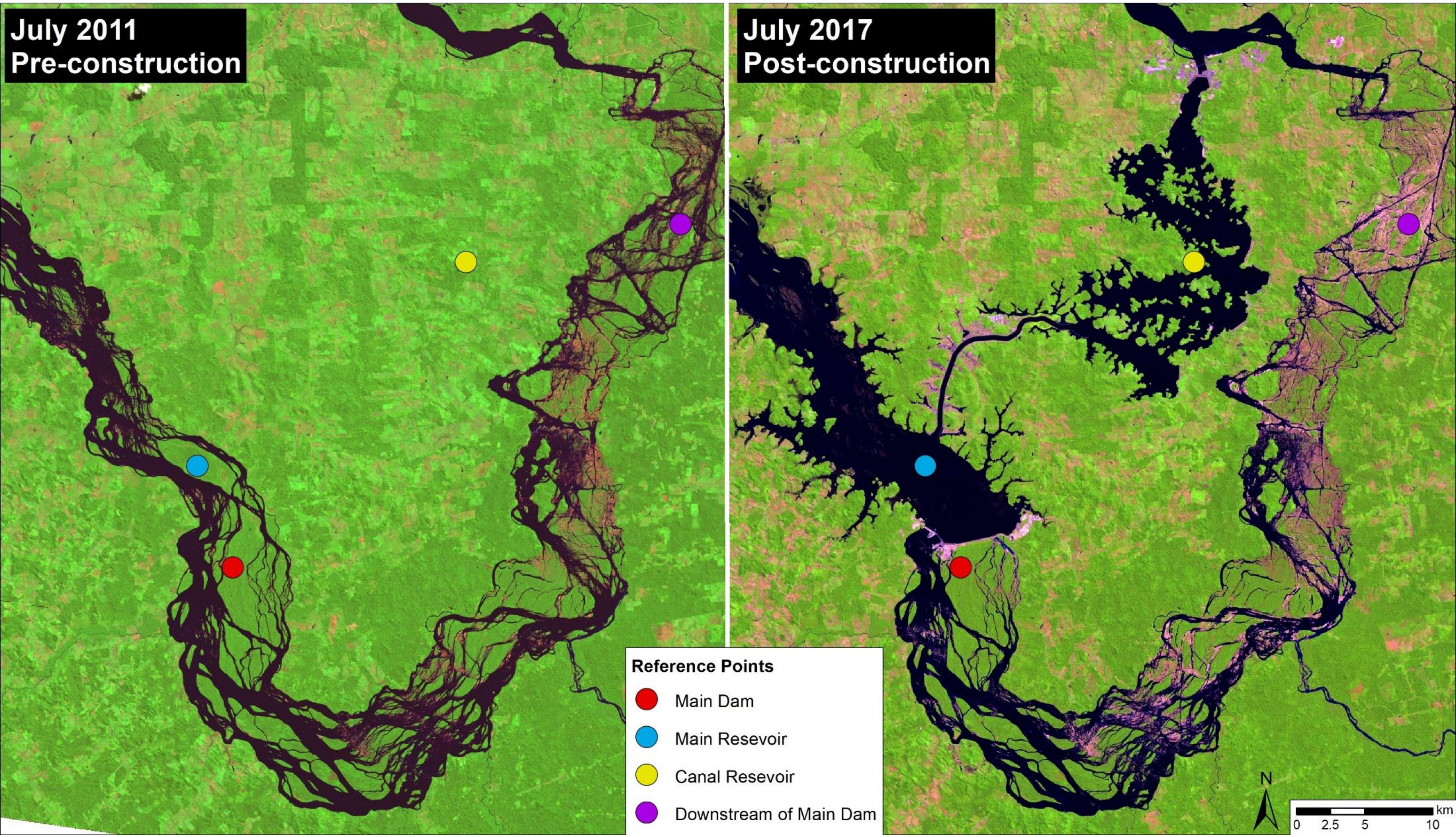
http://www.economist.com/news/americas/21577073-having-spent-heavily-make-worlds-third-biggest-hydroelectric-project-greener-brazil

Belo Monte

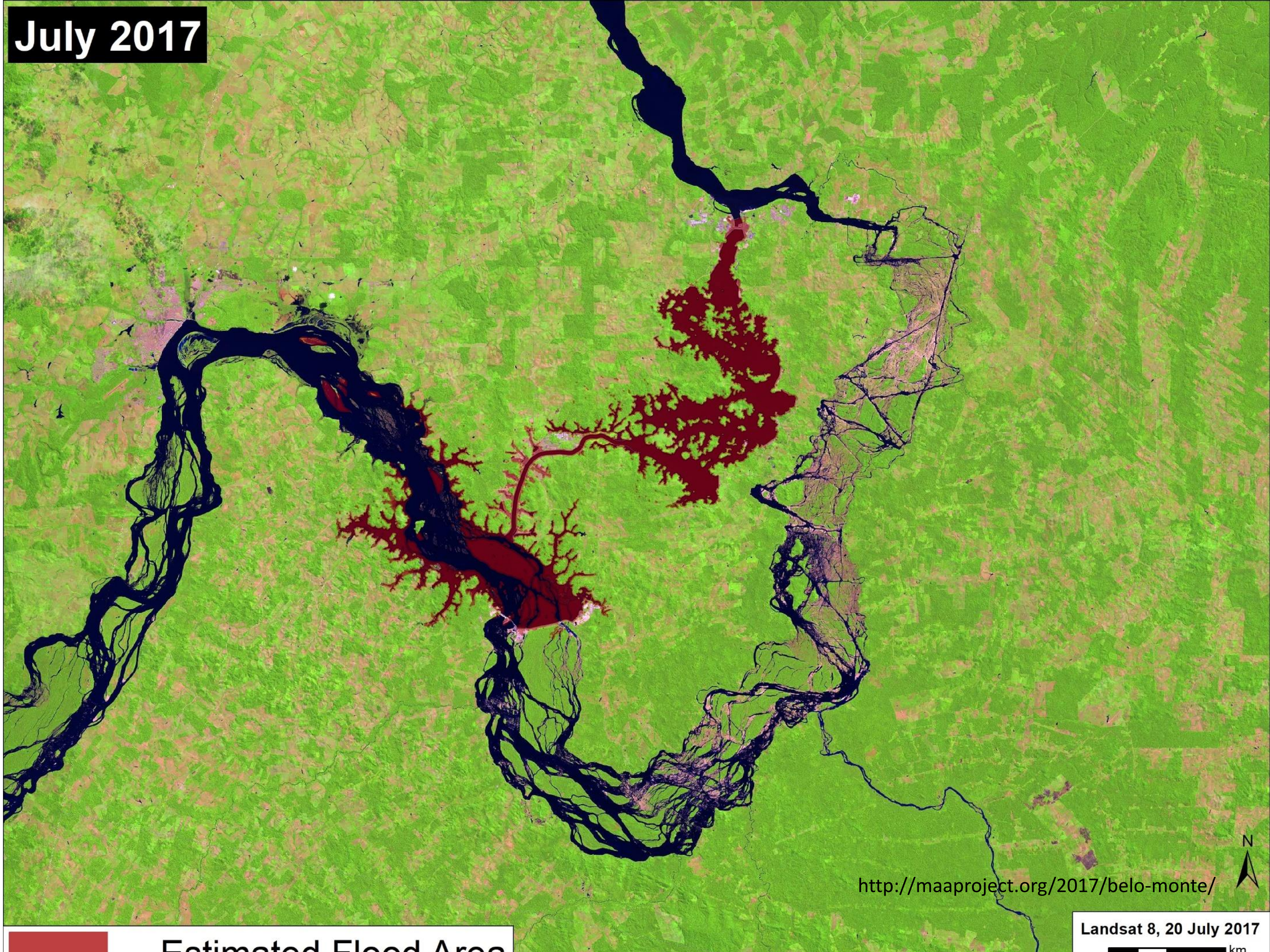
https://e360.yale.edu/features/how-a-dam-building-boom-is-transforming-the-brazilian-amazon

https://news.mongabay.com/2020/01/belo-monte-boondoggle-brazils-biggest-costliest-dam-may-be-unviable/

https://news.mongabay.com/2020/01/belo-monte-boondoggle-brazils-biggest-costliest-dam-may-be-unviable/



http://maaproject.org/2017/belo-monte/


July 2017
http://maaproject.org/2017/belo-monte/
N
Landsat 8, 20 July 2017
km
Estimated Flood Area

Hoover Dam (USA)
1936

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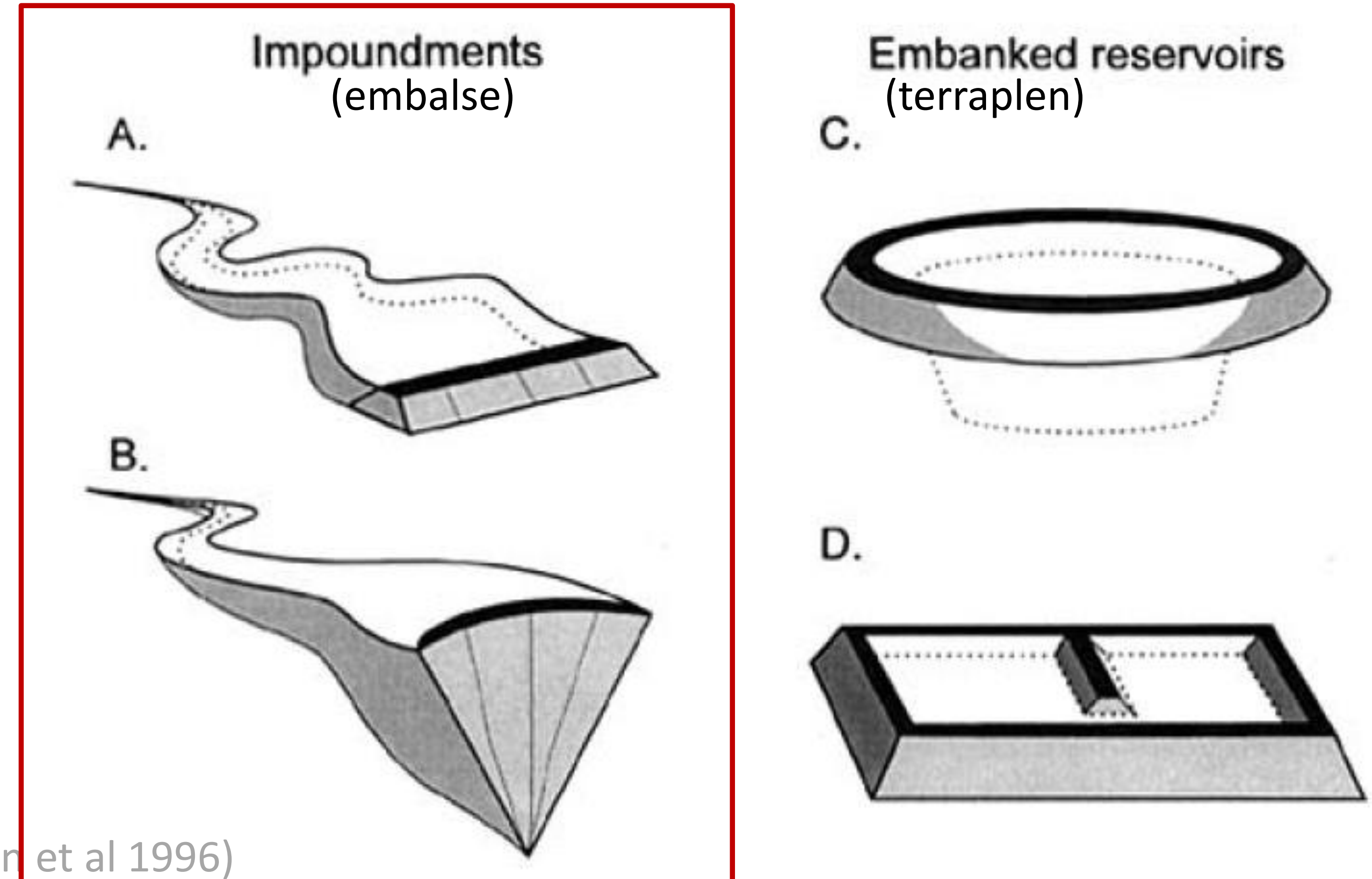
Represa, embalse / Pantano (España) / *Reservoir, dam, impoundment*
RESERVORIOS

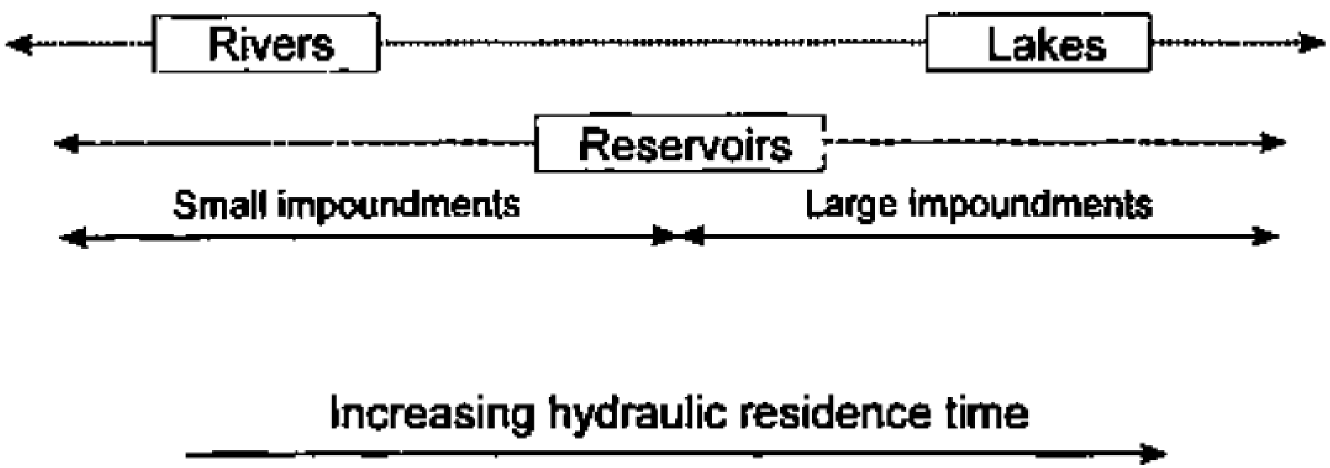
Figure 8.3 Examples of the principal reservoir configurations: A. shallow, 'U' shaped; B. deep, 'V' shaped; C. deep, regular; D. shallow, regular



(Thornton et al 1996)

Caracterísicas

Figure 8.2 The intermediate position of reservoirs between rivers and natural lakes is determined by their water residence time and degree of riverine influence (Based on Kimmel and Groeger, 1984)



(Thornton et al 1996)

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Dinámica / zonación

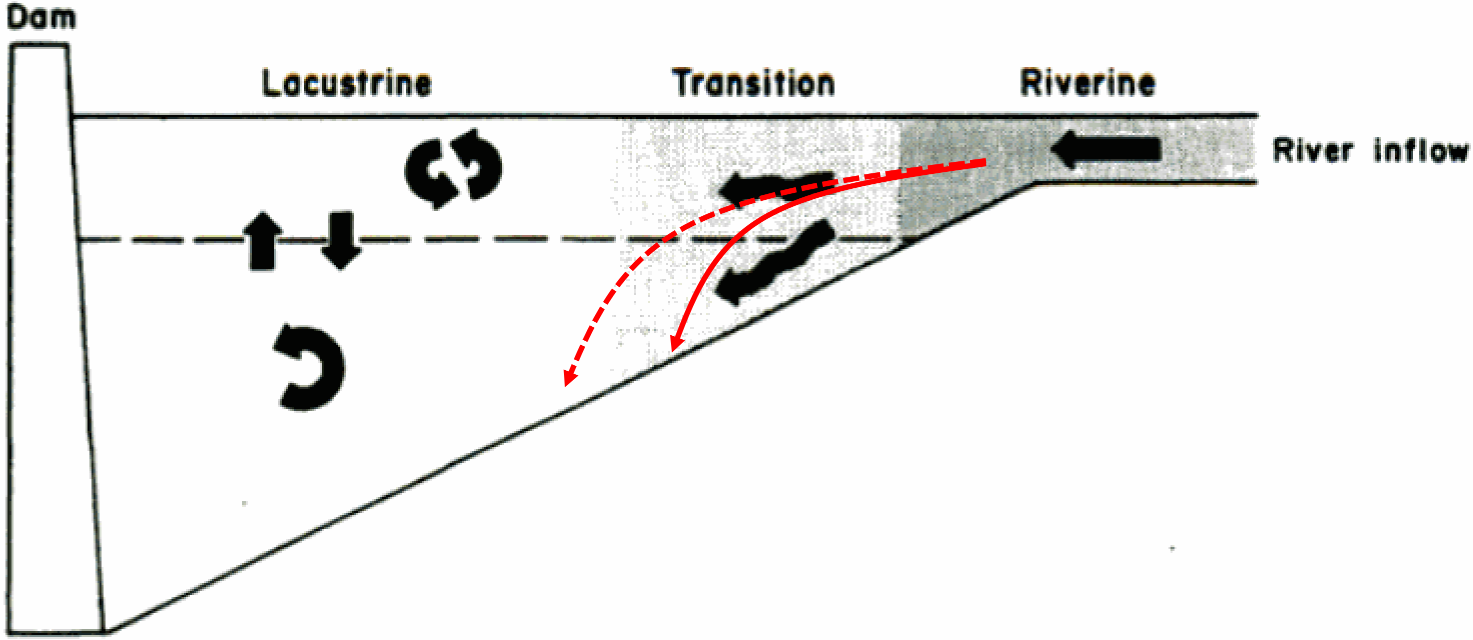
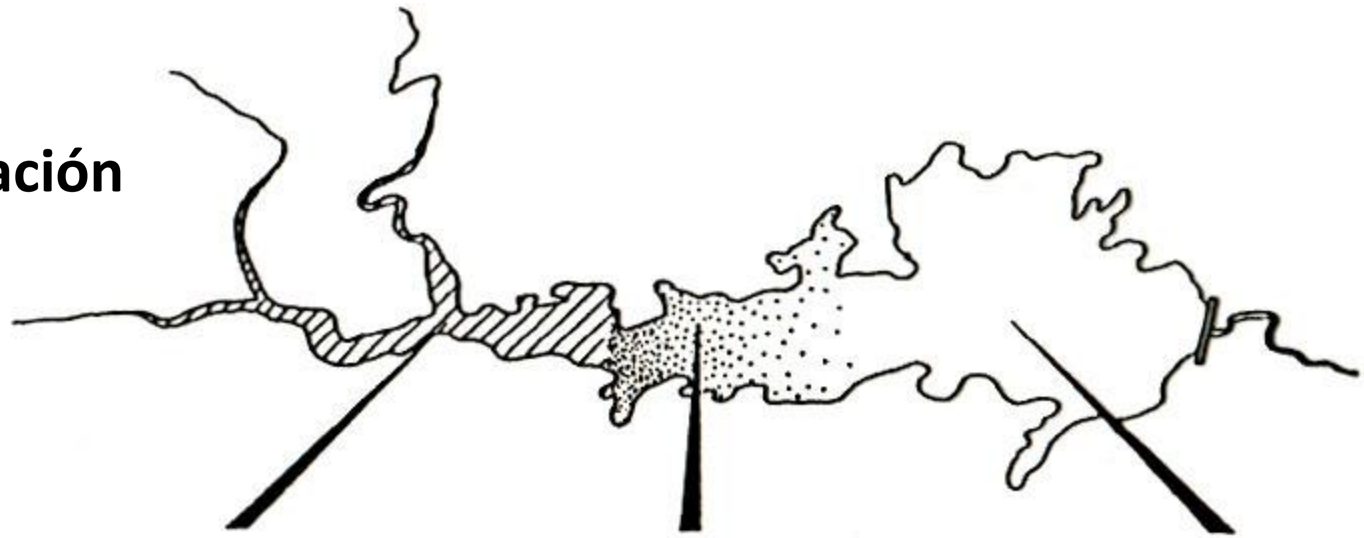


Figure 1.10 Three distinct zones resulting from gradients in reservoirs.

(Thornton et al 1996)

Zonación



RIVERINE ZONE	TRANSITIONAL ZONE	LACUSTRINE ZONE
• NARROW, CHANNELIZED BASIN	• BROADER, DEEPER BASIN	• BROAD, DEEP, LAKE-LIKE BASIN
• RELATIVELY HIGH FLOW	• REDUCED FLOW	• LITTLE FLOW
• HIGH SUSP. SOLIDS. TURBID, LOW LIGHT AVAIL.	• REDUCED SUSP. SOLIDS, LESS TURBID, LIGHT AVAIL. INCREASED	• REL. CLEAR, LIGHT MORE AVAIL. AT DEPTH, $Z_p > Z_m$
• NUTRIENT SUPPLY BY ADVECTION, REL. HIGH NUTRIENTS	• ADVECTIVE NUTRIENT SUPPLY REDUCED	• NUTRIENT SUPPLY BY INTERNAL RECYCLING, REL. LOW NUTRIENTS
• LIGHT-LIMITED PPR	• PPR/m^3 REL. HIGH	• NUTRIENT-LIMITED PPR
• CELL LOSSES PRIMARILY BY SEDIMENTATION	• CELL LOSSES BY SEDIMENTATION AND GRAZING	• CELL LOSSES PRIMARILY BY GRAZING
• ORGANIC MATTER SUPPLY PRI-ALLOCHTHONOUS, P < R	• INTERMEDIATE	• ORGANIC MATTER SUPPLY PRIMARILY AUTOCHTHONOUS, P > R
• MORE "EUTROPHIC"	• INTERMEDIATE	• MORE "OLIGOTROPHIC"

(Thornton et al 1996)

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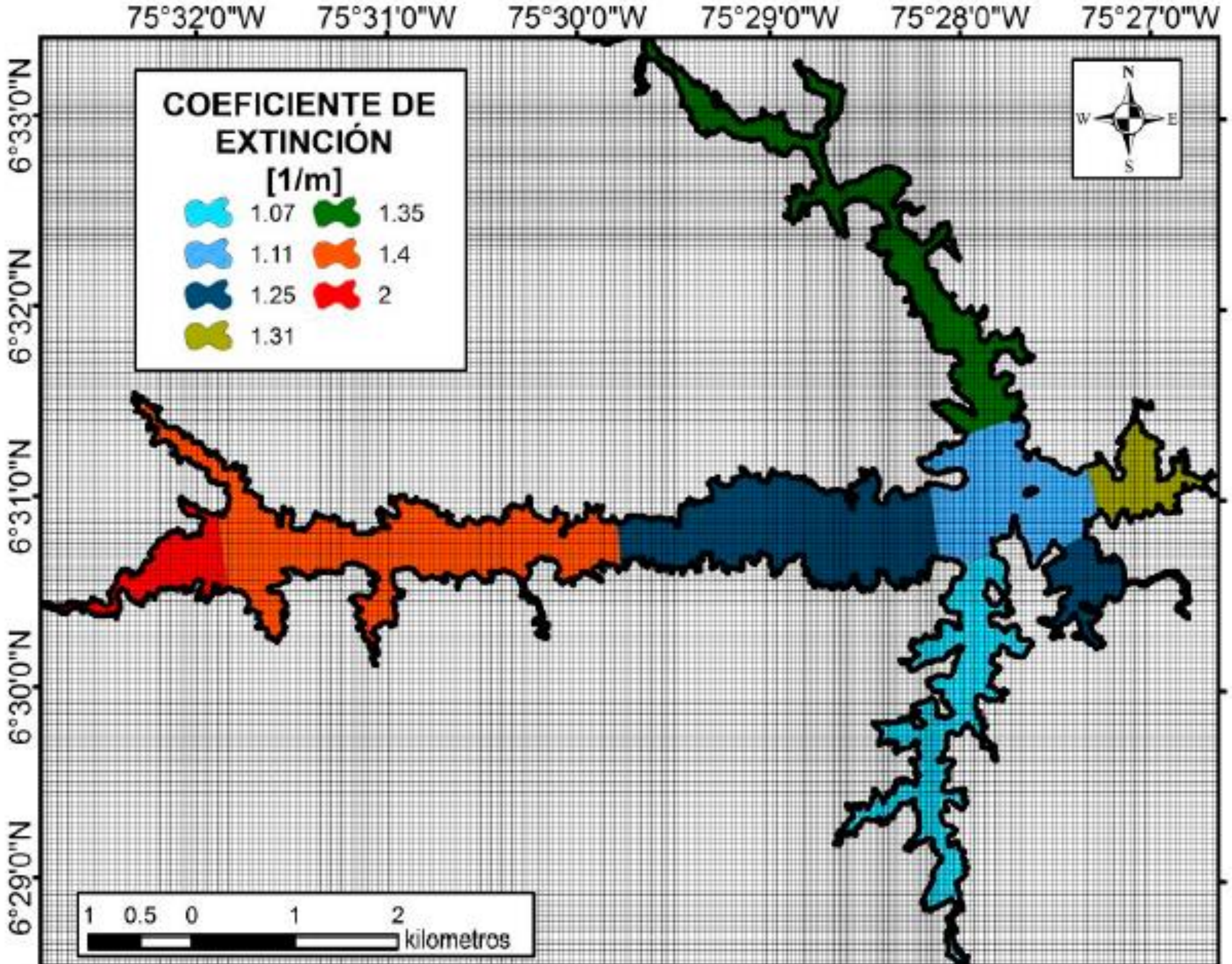

75°32'0"W
75°31'0"W
75°30'0"W
75°29'0"W
75°28'0"W
75°27'0"W
6°33'0"N
6°32'0"N
6°31'0"N
6°30'0"N
6°29'0"N
COEFICIENTE DE EXTINCIÓN [1/m]
1.07
1.35
1.11
1.4
1.25
2
1.31
N
W
E
S
1 0.5 0 1 2
kilometros

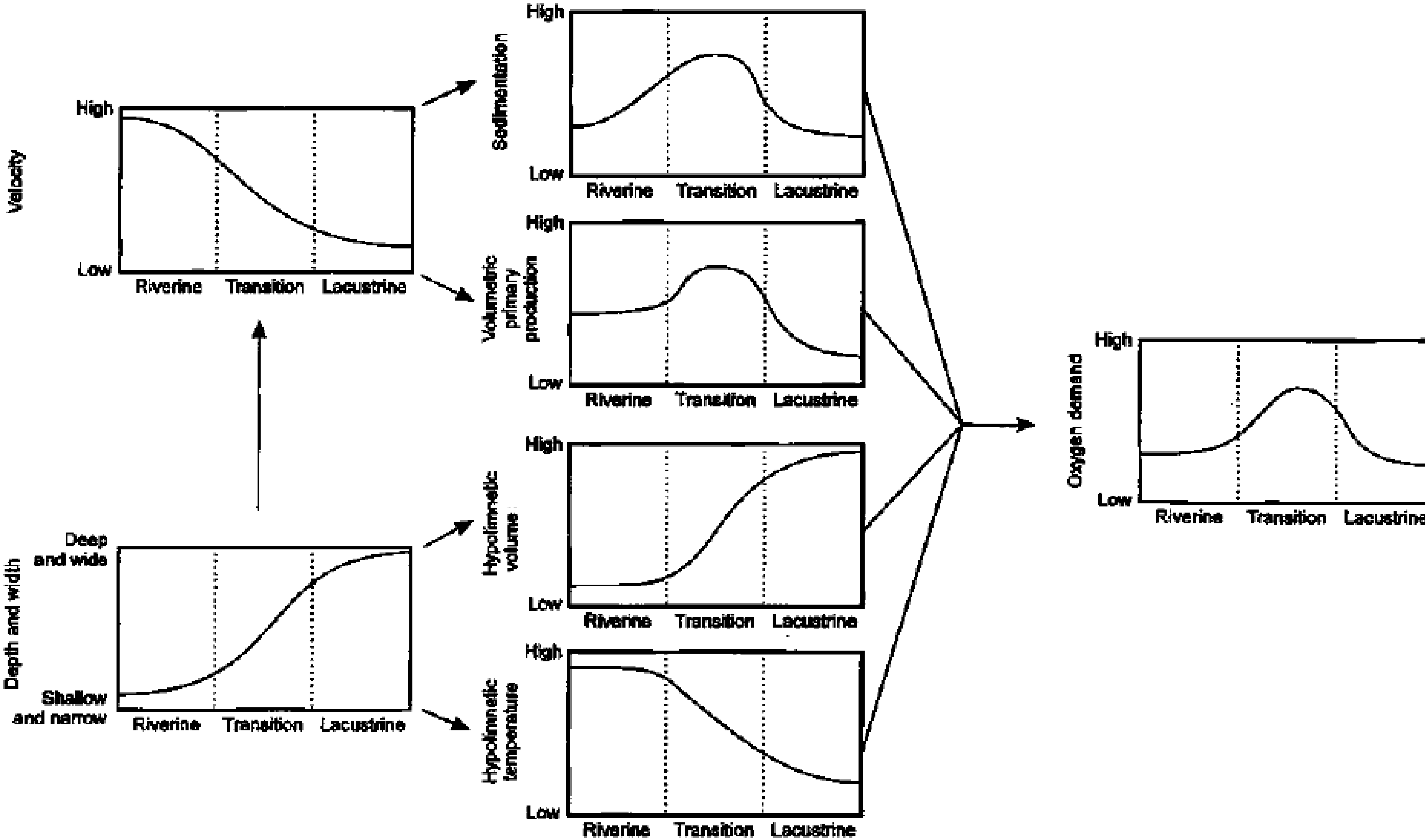
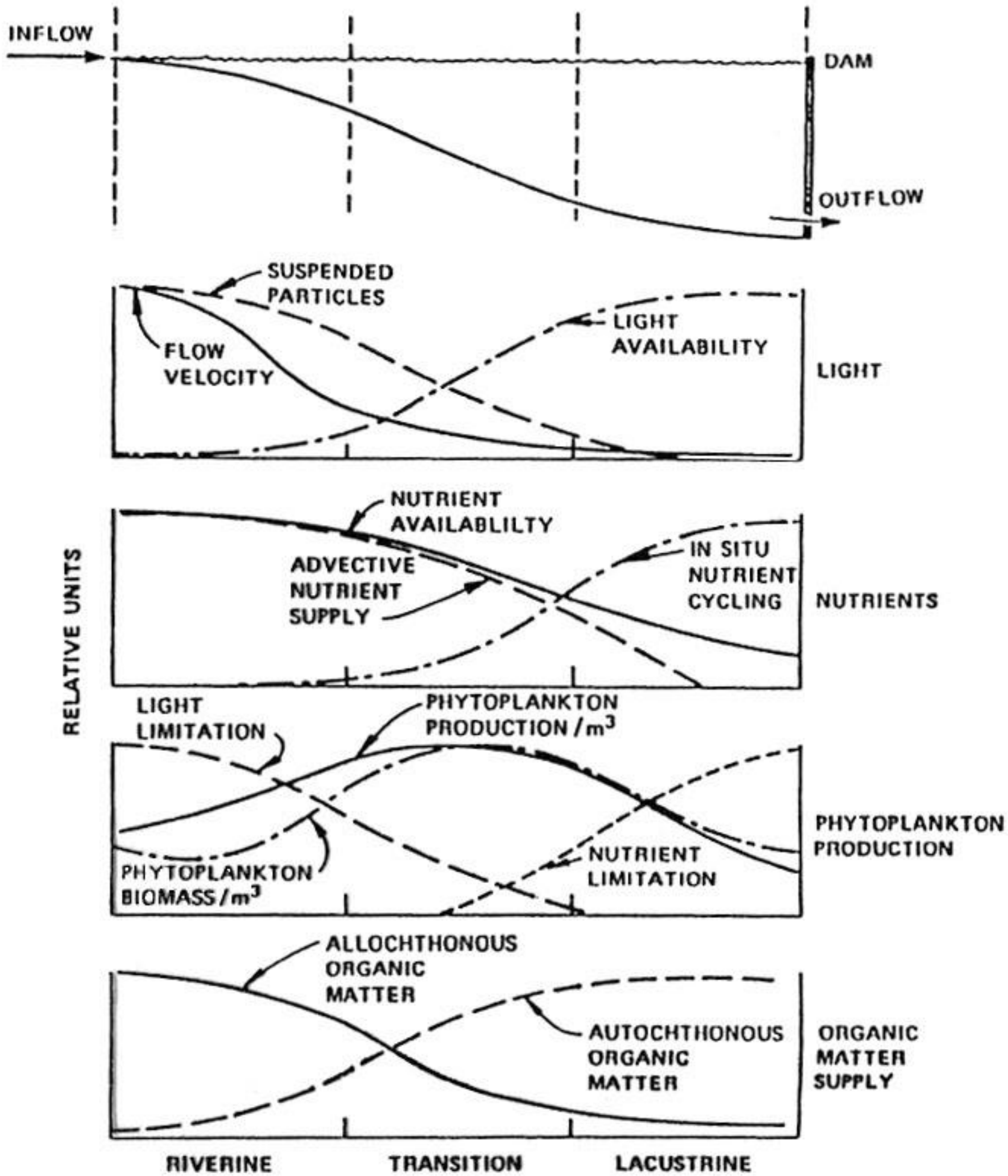


Figure 8.10 Relationship of morphometry, retention time and longitudinal variation in water quality process rates to oxygen demand along the length of a reservoir (see also Figure 8.4) (After Cole and Hannan, 1990) Reproduced by permission of John Wiley & Sons, Inc.

(Thornton et al 1996)

Zonación



(Thornton et al 1996)

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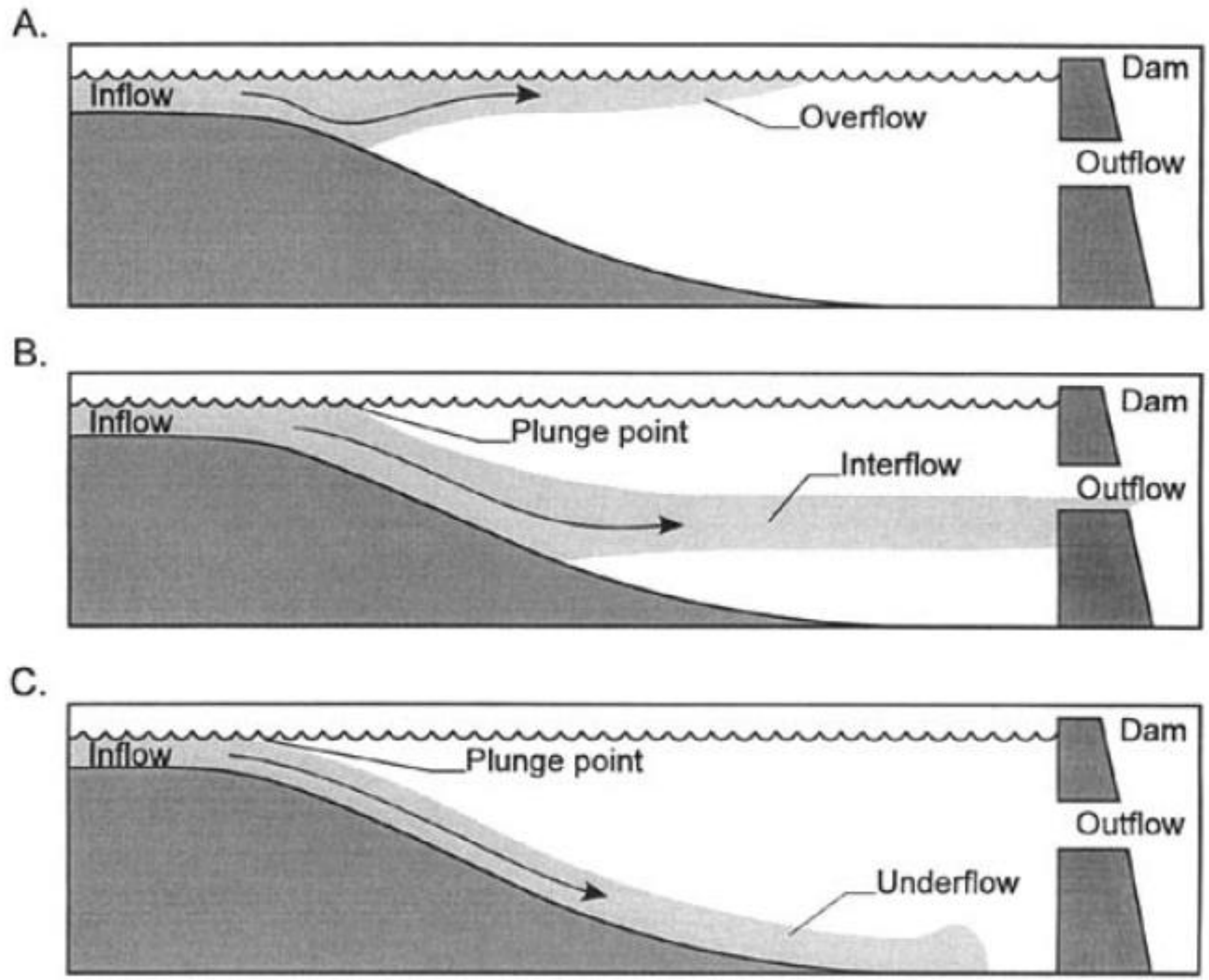

(Thornton et al 1996)

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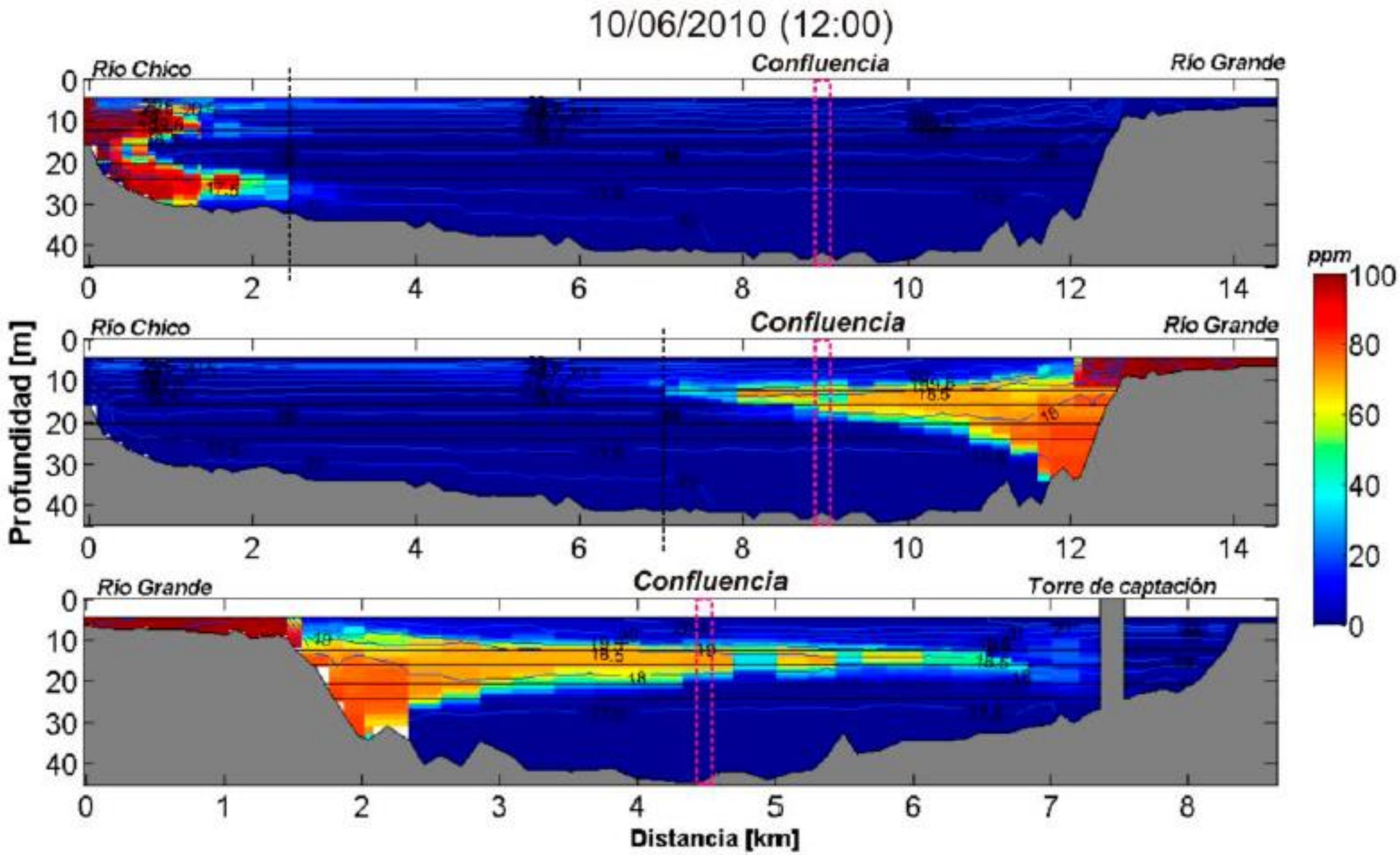
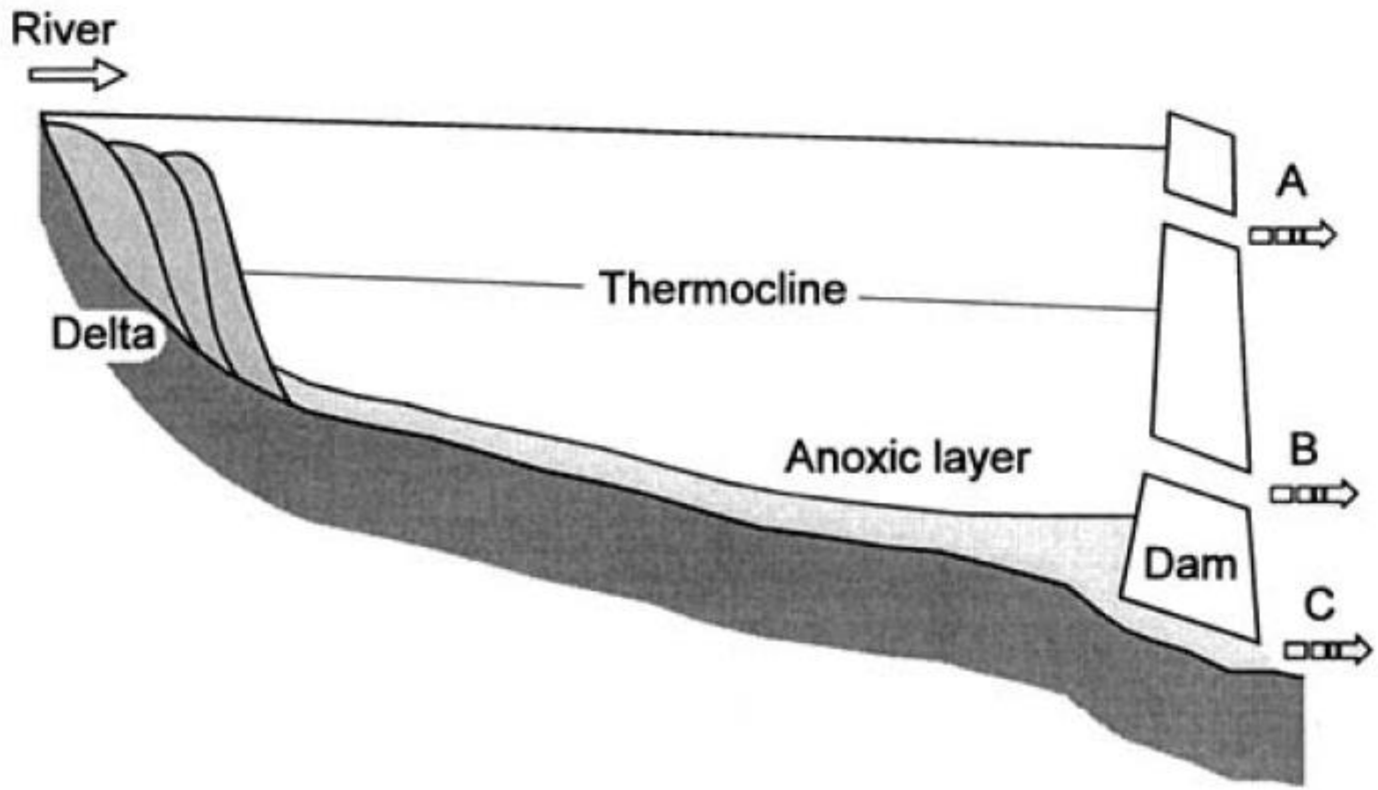


Figura 5-14: Desarrollo de la entrada de las plumas de los ríos Grande y Chico en el embalse Riogrande II - Caso de simulación con el embalse en condición de nivel medio e hidrográfas sincronizadas.



(Thornton et al 1996)

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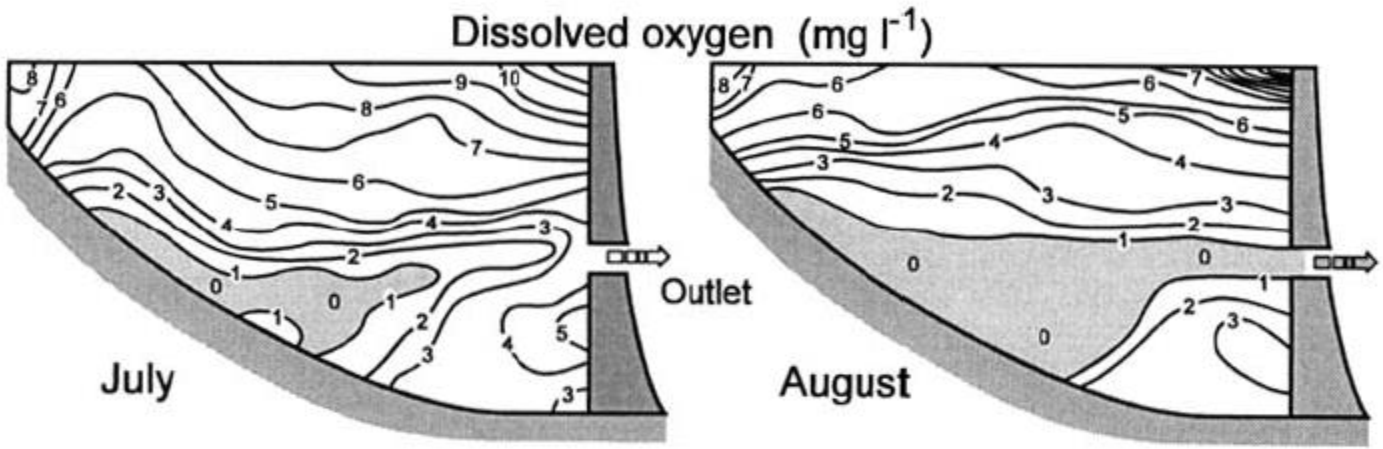
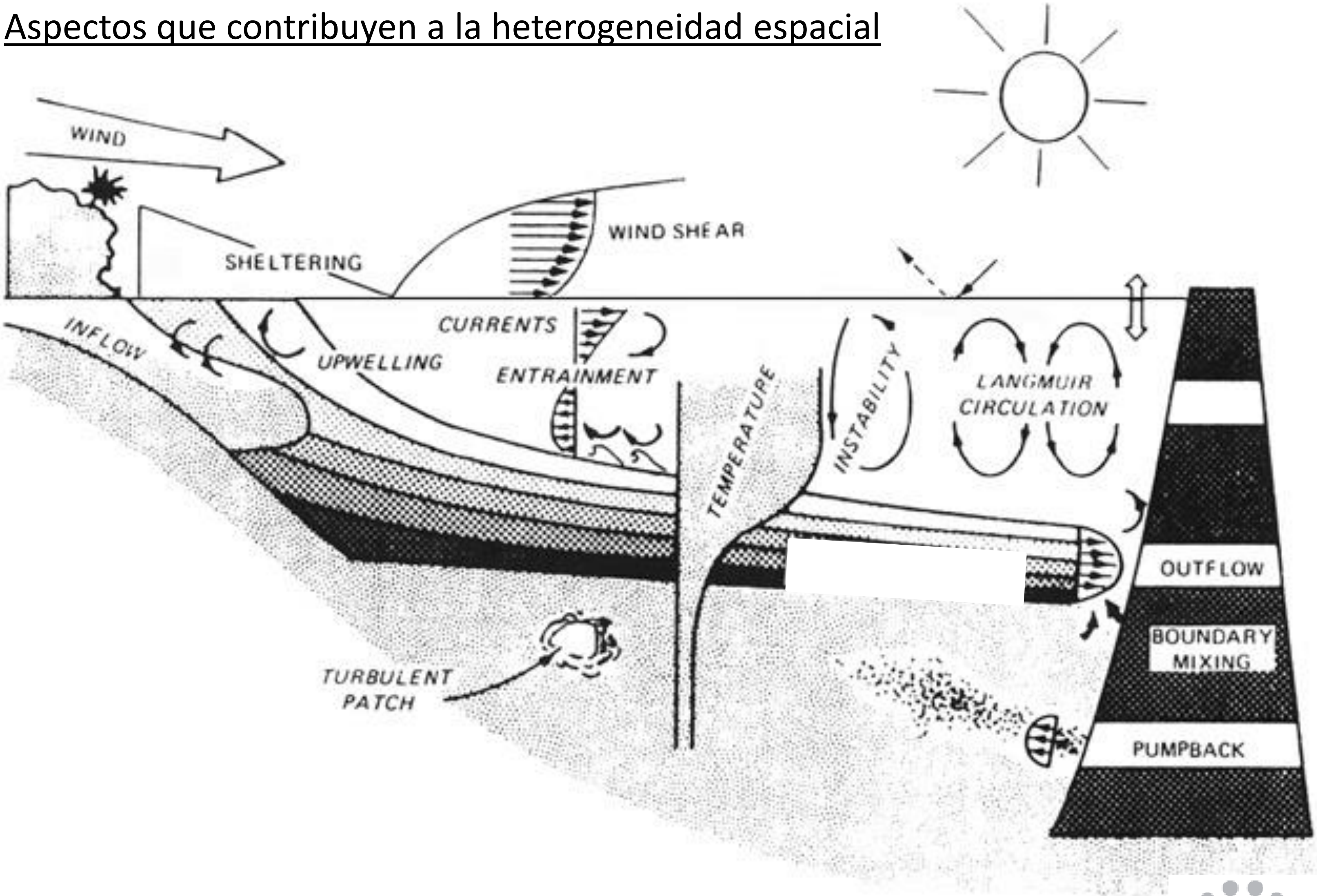
Figure 8.11 An example of modifications in the depth distribution of dissolved oxygen by currents caused by mid-depth water withdrawal (Based on Ebel and Koski, 1968)



(Thornton et al 1996)

Aspectos que contribuyen a la heterogeneidad espacial



(Thornton et al 1996)

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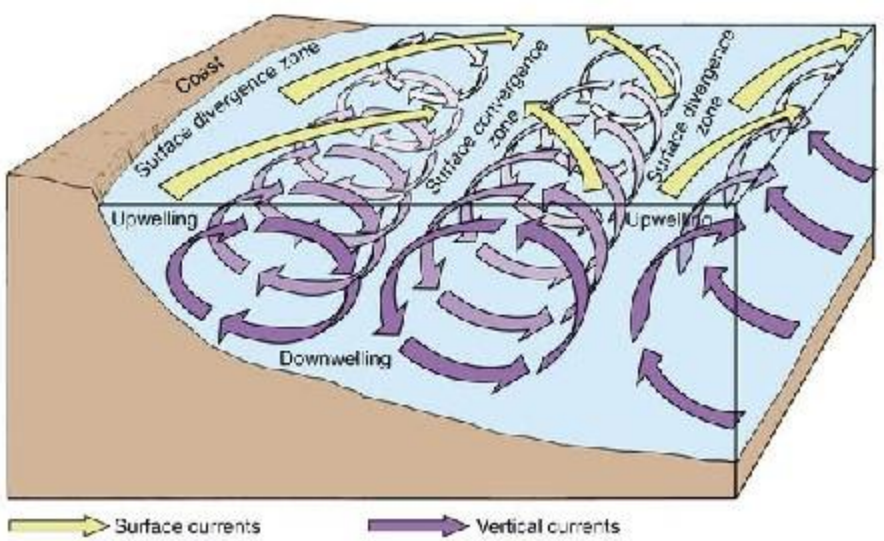
Apunte: Circulación de Langmuir

<u>Apunte</u>: Circulación de Langmuir



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¿Cuáles serán los productores primarios predominantes?

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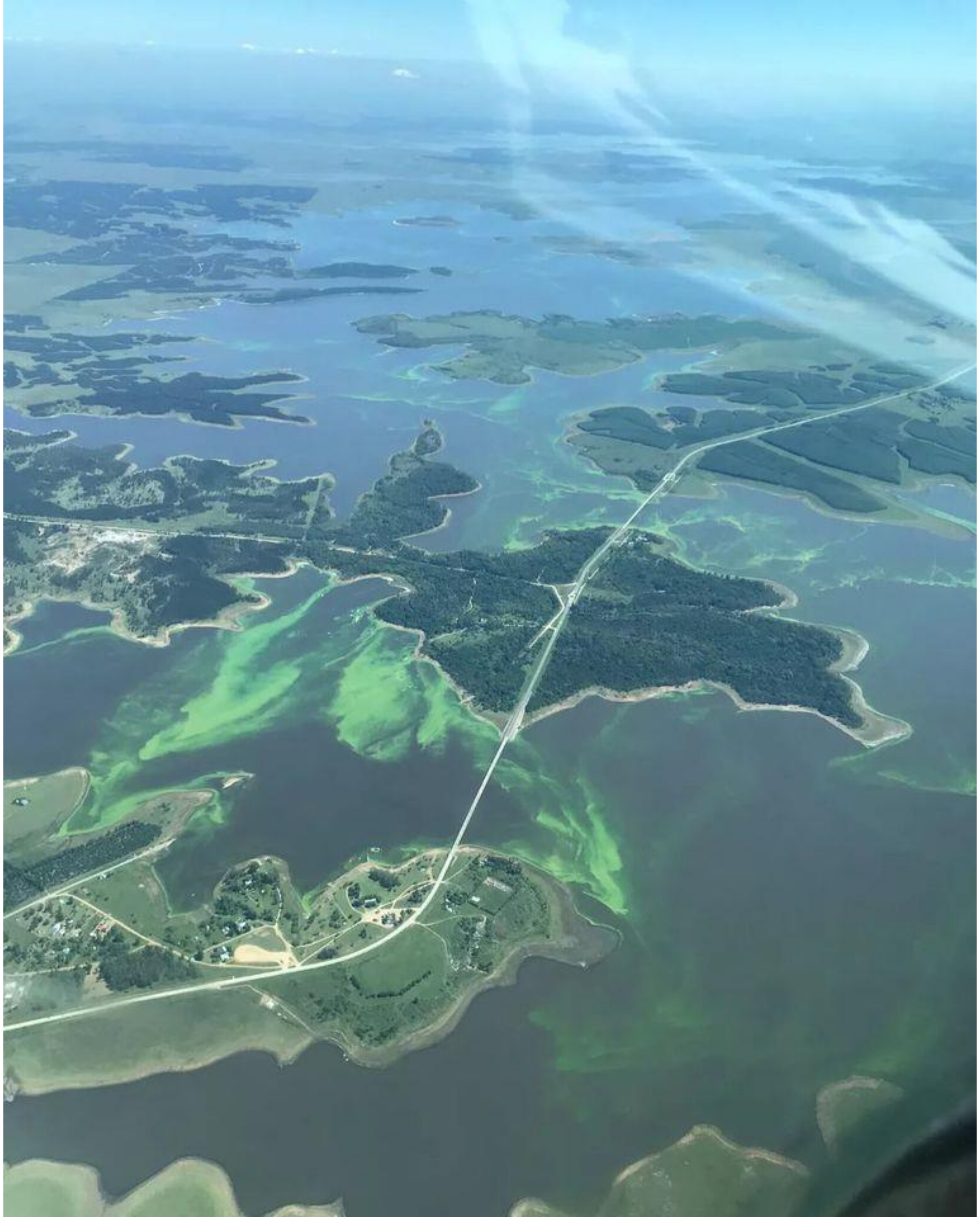
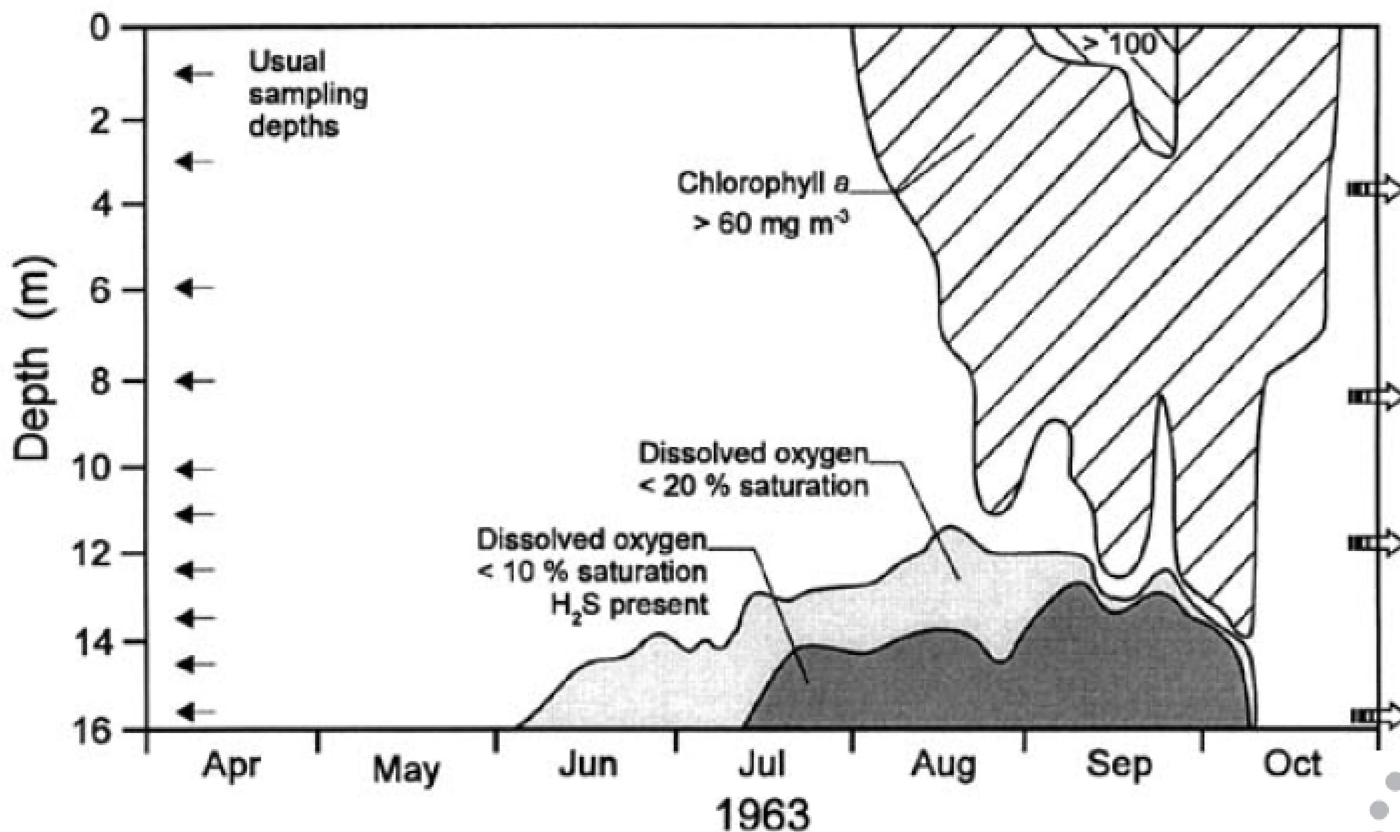


https://www.facebook.com/photo/?fbid=439669307956076&set=a.114822353774108

Figure 8.18 Depths distributions of chlorophyll a and dissolved oxygen concentrations in relation to the water withdrawal points in the highly eutrophic King George VI reservoir, UK, during the summer months, prior to the application of any management regime (compare with the managed reservoir in Figure 8.12) (After Steel, 1972)



(Thornton et al 1996)

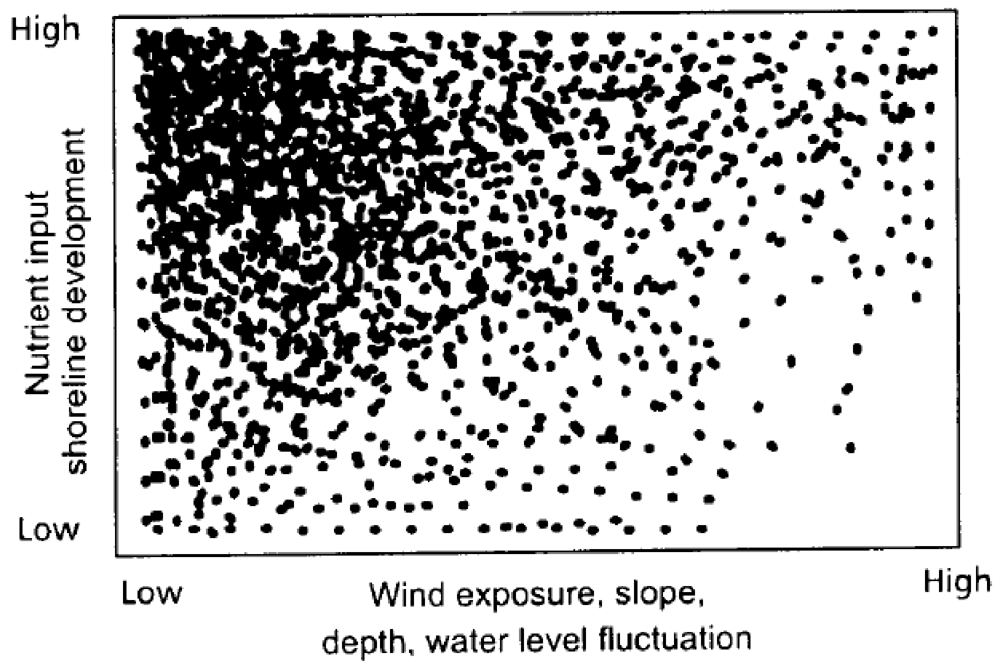


Figure 5 Hypothetical tendency of colonization of aquatic macrophytes in reservoirs. The degree of colonization is directly related with points density (after Thomaz and Bini, 1998b).

(Tundisi & Straskraba 1999)

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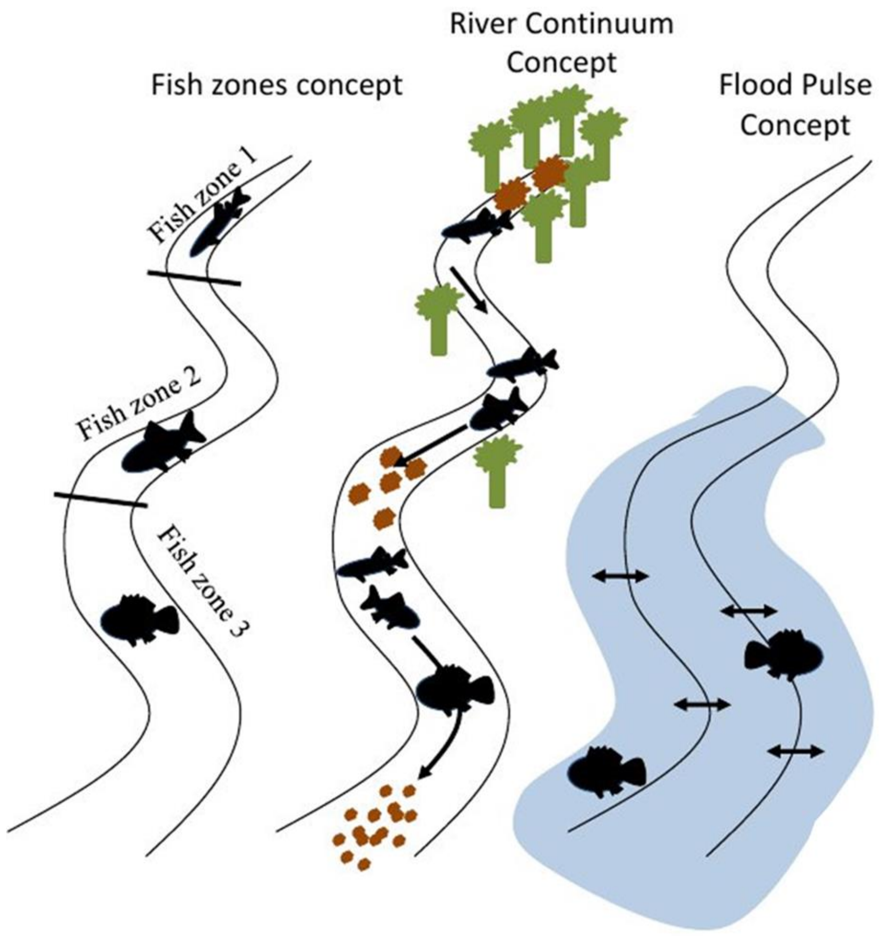
Represa, embalse / Pantano (España) / *Reservoir, dam, impoundment*
RESERVORIOS

Efectos "colaterales":

Alteración del régimen hidrológico natural:

1. Inundaciones en regiones de aguas arriba
2. Inundan y crean nuevos hábitats
3. Aumentan el volumen de agua evaporada
4. Merma de los caudales circulantes aguas abajo
5. Modificación de las condiciones geomorfológicas del cauce (sedimentación)
6. Alteración de las zonas bajas que perturba el ciclo natural de peces y otros organismos acuáticos (alteración de corredores ecológicos naturales)
7. Alteración de los hábitats y los paisajes fluviales: fragmentación del hábitat
8. Desaparecen tierras cultivables, dificulta la navegación fluvial
9. Modifican la calidad del agua
10. Emiten gases de efecto invernadero
11. Desplazamiento de comunidades enteras
12. Cambios forzados en las actividades de subsistencia

Presas y funcionamiento de ecosistemas lóticos



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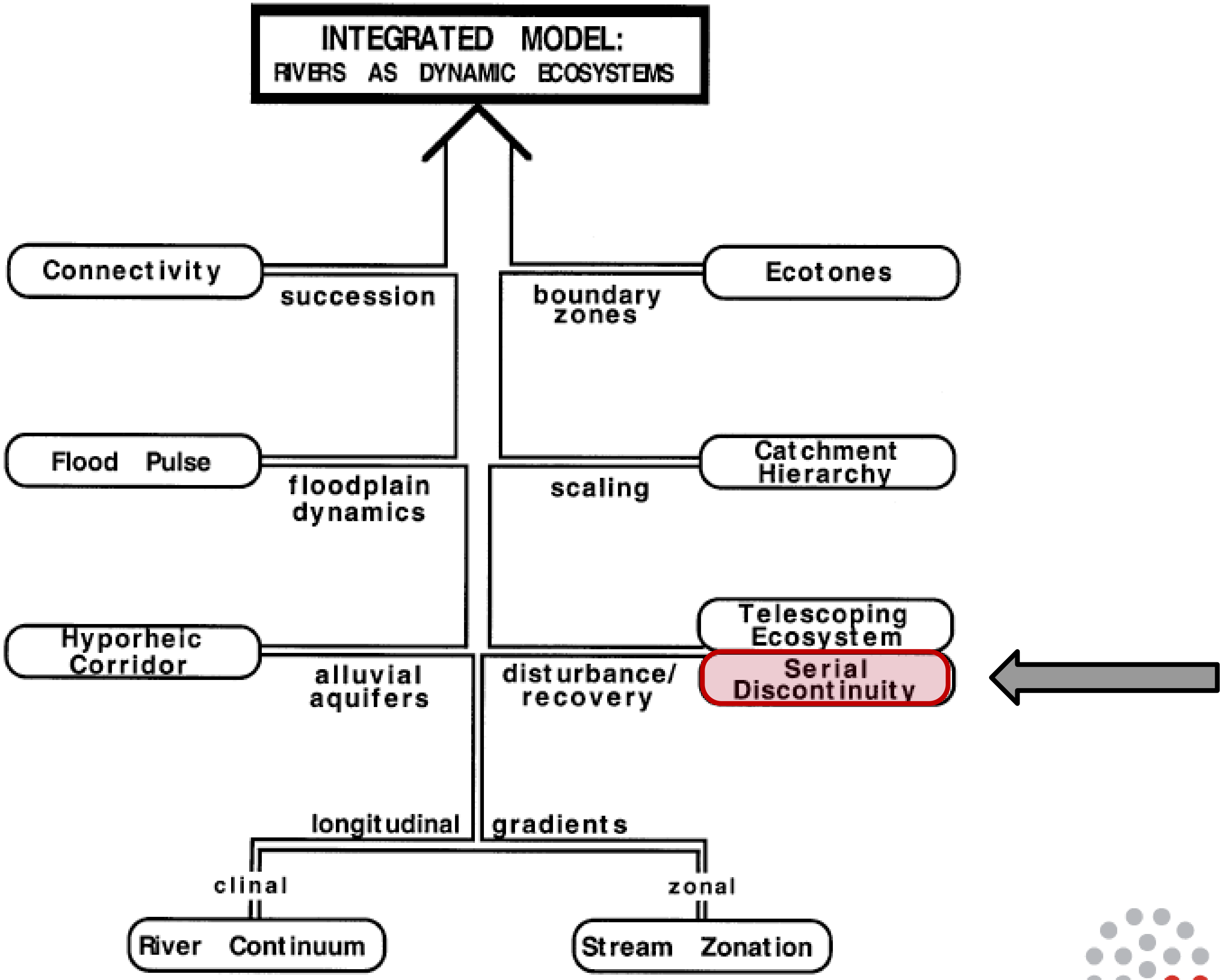

Ward et al 2002

Discontinuidad seriada

De acuerdo a la hipótesis del continuo las comunidades se organizan espacialmente de acuerdo a la variación de las propiedades físicas y químicas del sistema, en consecuencias las diferentes comunidades también presentan un continuo en algunos de sus atributos o propiedades; la construcción de una represa crea una discontinuidad.

Ej.
P/R ratio ?
Hetrogeneidad ambiental?

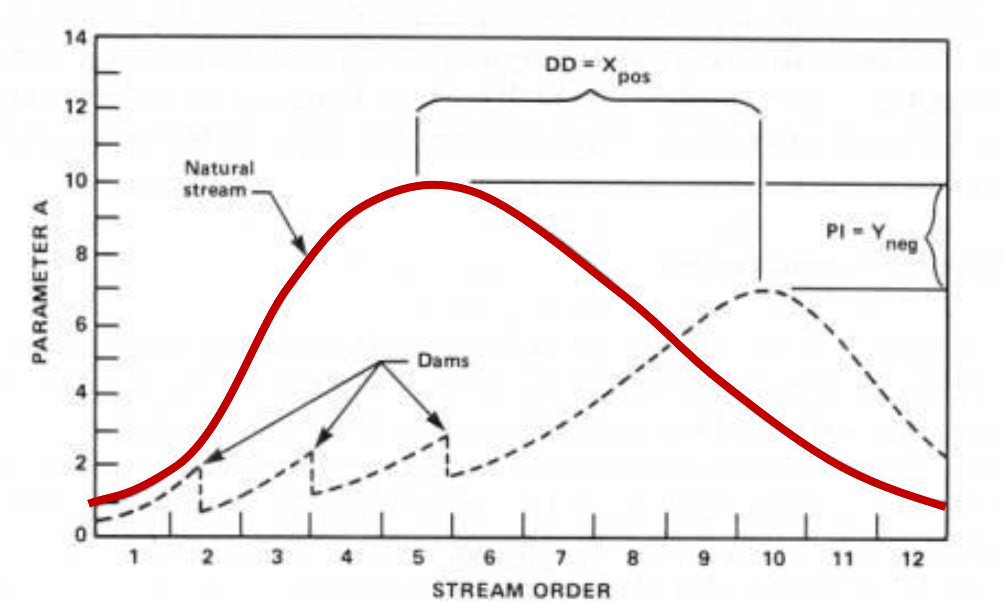

Figure 3. Theoretical framework for conceptualizing the influence of impoundment on ecological parameters in a river system. Discontinuity distance (DD) is the downstream (positive) or upstream (negative) shift of a parameter a given distance (X) due to stream regulation. PI is a measure of the difference in the parameter intensity attributed to stream regulation.

Ward, J. V., 1983. The serial discontinuity concept of lotic ecosystems. In Fontaine, T. D. & S. M. Bartell (eds) *Dynamics of Lotic Ecosystems. Ann Arbor Sci., Ann Arbor, MI, 29-42.*

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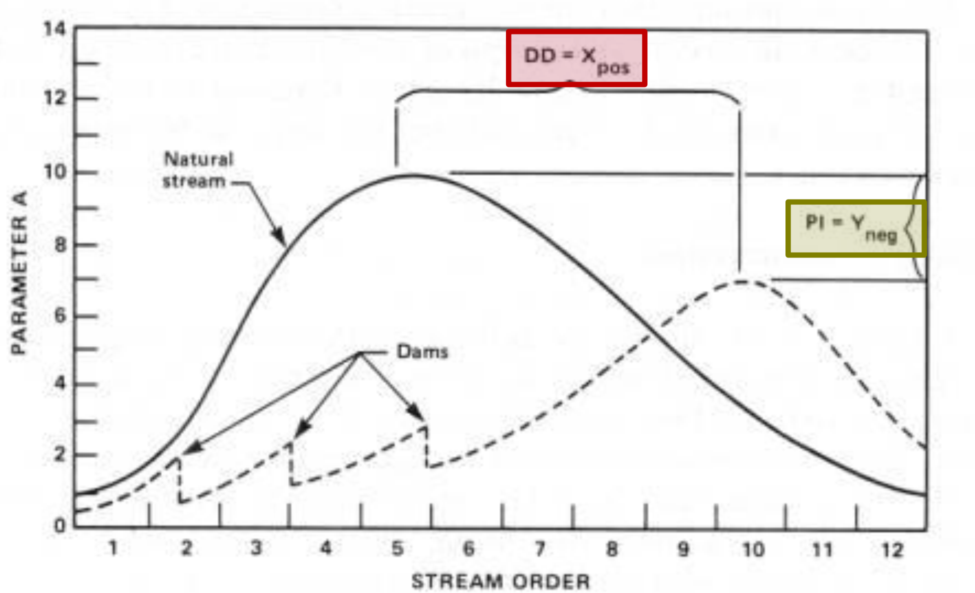
Discontinuidad seriada

Estas condiciones alteradas por la construcción de una presa son reestablecidas aguas abajo, estas generalmente se identifican y se cuantifican en términos de la distancia en que existe una recuperación de las características estudiadas (DD) y de la magnitud de la diferencia.

Ej.
P/R ratio
Hetrogeneidad ambiental



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Discontinuidad seriada

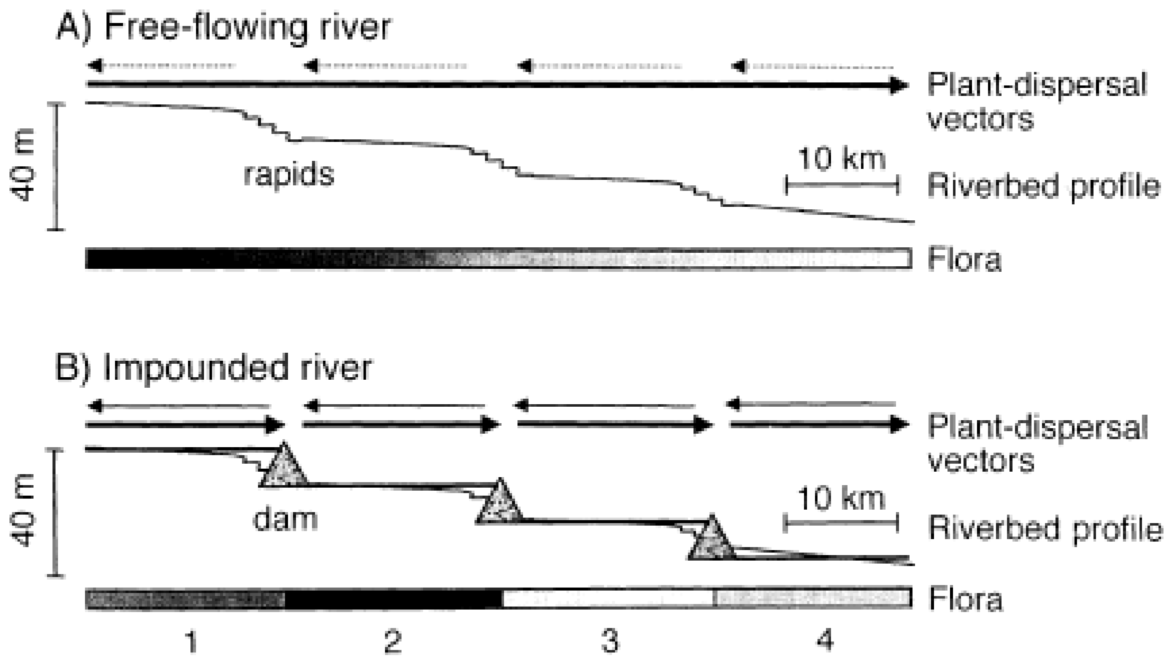

Figure 1-2. *Hypothesized relationships between plant-dispersal vectors, riverbed profile, and composition of the riparian flora in free-flowing versus impounded rivers. (A) The flora in the free-flowing river is hypothesized to describe a gradual change downstream, whereas (B) in the regulated river, each impoundment is projected to develop an individual flora (denoted 1–4). (From Jansson et al., 2000a, copyright © Ecological Society of America; reprinted by permission.)*

cascaded reservoirs

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GRANDES REPRESAS Y COMUNIDAD DE PECES

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GRANDES REPRESAS Y COMUNIDAD DE PECES

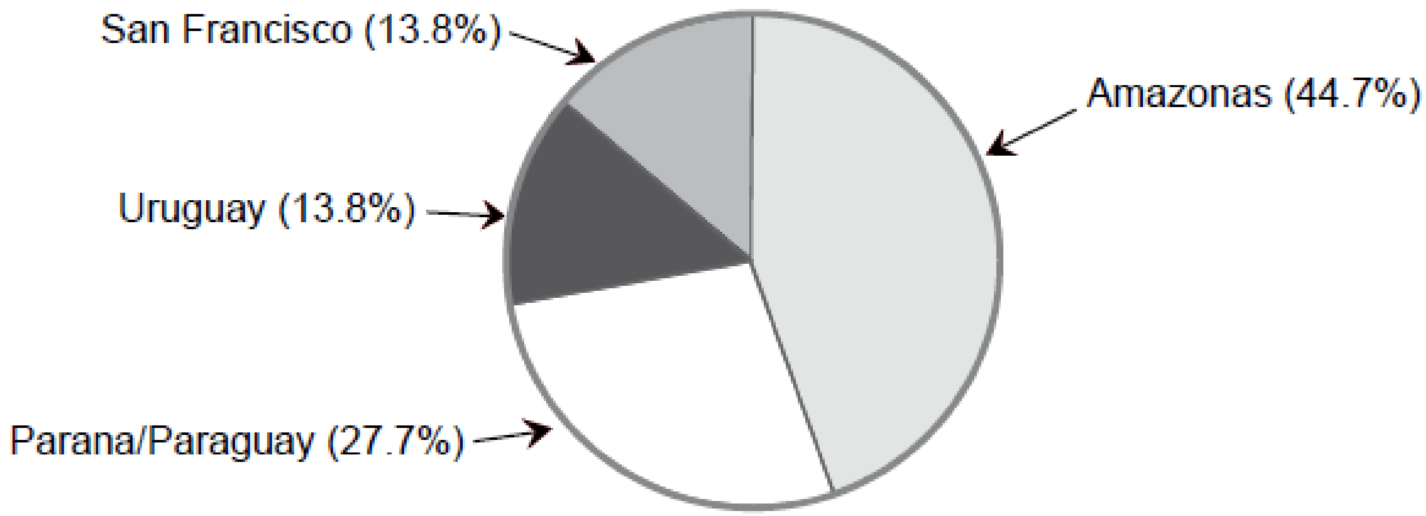

Figura 16.4. Porcentaje de especies migradoras por cuenca (adaptado de Agostinho *et al*., 2007a)

http://www.faunagua.org/biblioteca/3Cap16.pdf

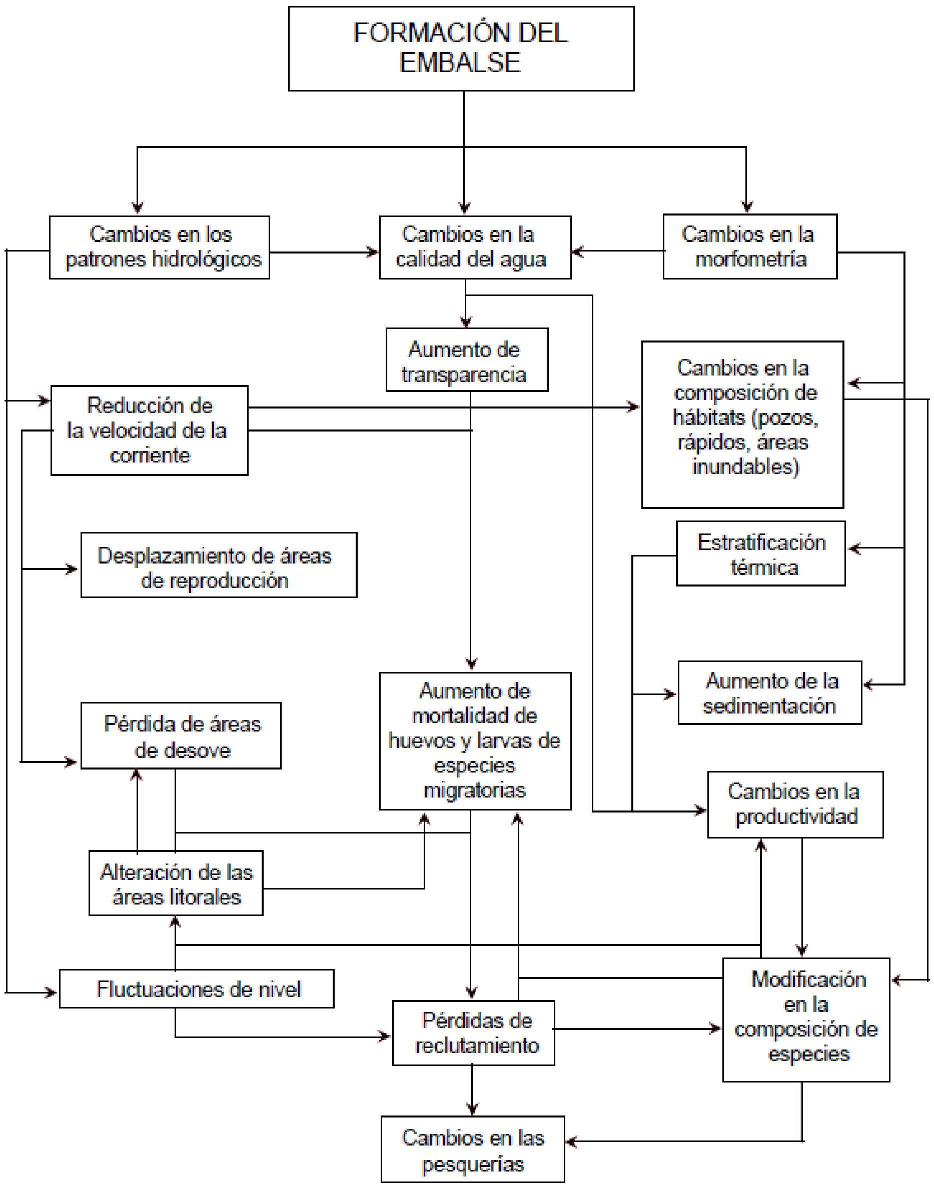

Figura 16.2. Potenciales impactos generados sobre las comunidades de peces aguas arriba de una represa, a partir de cambios en factores ambientales relevantes que ocurren por la construcción de un embalse (Elaboración propia)

http://www.faunagua.org/biblioteca/3Cap16.pdf

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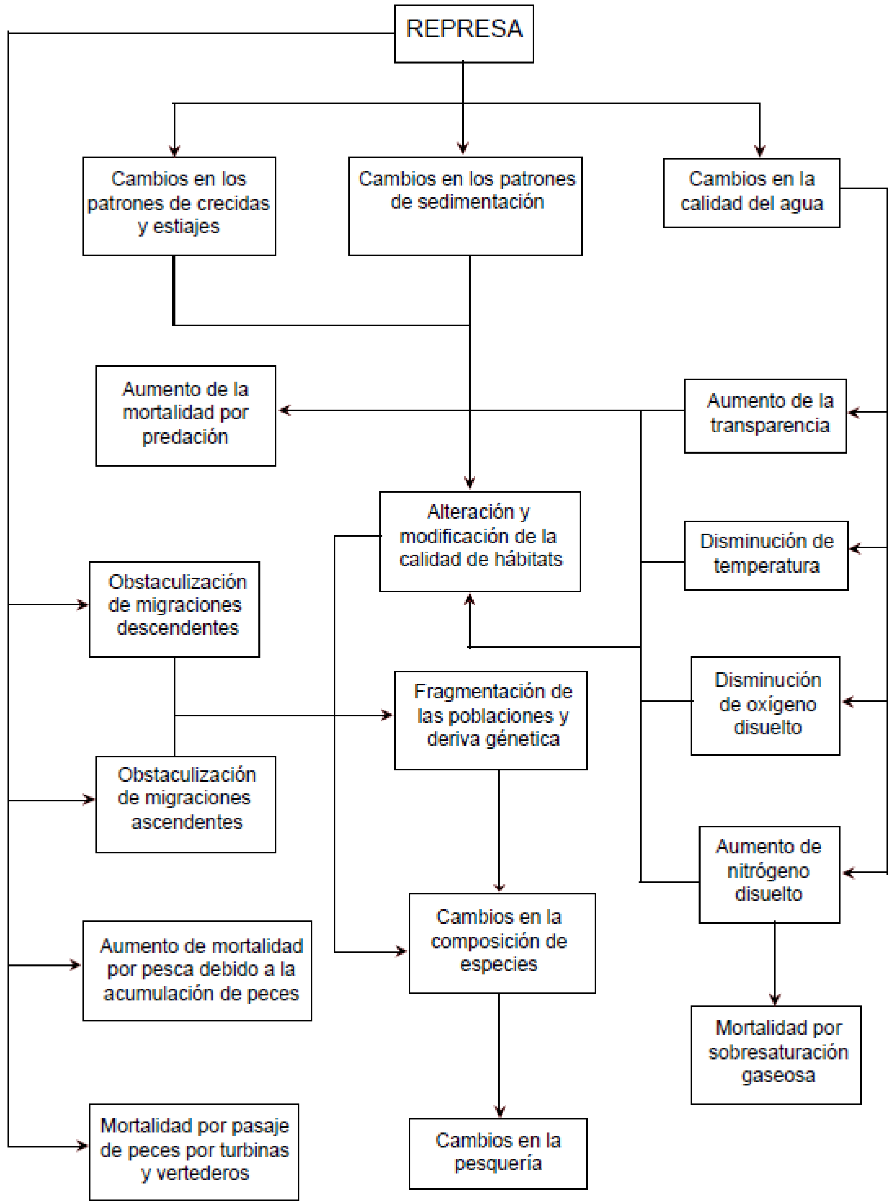

Figura 16.3. Potenciales impactos generados sobre las comunidades de peces aguas abajo de una represa, a partir de cambios en factores ambientales relevantes que ocurren por la construcción de un embalse (Elaboración propia)

http://www.faunagua.org/biblioteca/3Cap16.pdf

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Cuadro 16.3. Comparación de diferentes sistemas de traspaso utilizados en ríos sudamericanos (adaptado de Oldani *et al.*, 2007).

Sistema	Ventajas	Desventajas	Ejemplos
Ranuras verticales ("vertical slots")	Permite operar con diferentes niveles de agua.	Ofrece dificultades de paso para especies de gran porte. Carece de áreas de descanso para los peces.	Represa de Iagarpava (río Grande, Brasi)
Escaleras (escalones-tanques) ("pool and weir")	Apropiadas para represas de baja altura y gran flexibilidad de diseños.	Alta selectividad de especies. Sensible a los cambios de caudal. Poca efectividad para especies de fondo.	Represa de Lajeado (río Tocantins, Brasil) Represa de Salta Morais (río Tijuco, cuenca alta del río Paraná, Brasil)
Ascensores	El costo es independiente de la altura de la represa. Requiere poco espacio para su instalación. Poco sensible a las variaciones de nivel del embalse.	Costo elevado de construcción, operación y manutención. Genera estrés en los peces y mortandad por aglomeración. El número de peces transferidos depende del volumen del ascensor y del tiempo del ciclo.	Represa Engenheiro, Represa Sergio Motta (río Paraná, Brasil) Represa de Funil (río Grande, Brasil) Yacyreta (río Paraná, Argentina-Paraguay) Represa Santa Clara (río Mucuri).
Esclusas ("fish locks")	Diseño flexible que puede ser adaptado a distintos tipos de represas hidroeléctricas.	Baja capacidad de transferencia. El número de peces transferido depende del número de ciclos diaríos. Durante la fase del llenado, el flujo de atracción se reduce o se elimina.	Represa de Salto Grande (río Uruguay, Argentina-Uruguay)
Sistemas de by-pass (ríos artificiales)	Alta capacidad de transferencia. Permiten simular las condiciones naturales del río. Amplio espectro de velocidades de agua Utilizables para migraciones descendentes. Proporcionan hábitats para especies residentes.	Requieren de un amplio espacio para su instalación cuando la altura de la represa es considerable debido a su baja pendiente. Susceptible a variaciones del nivel de agua en el reservorío. Riesgo de introducción de especies no-deseadas.	Canal de Piracema, Represa Itaipú, río Paraná (Paraguay-Brasil)

Ej. 1

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Ej. 2

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Ej. 3

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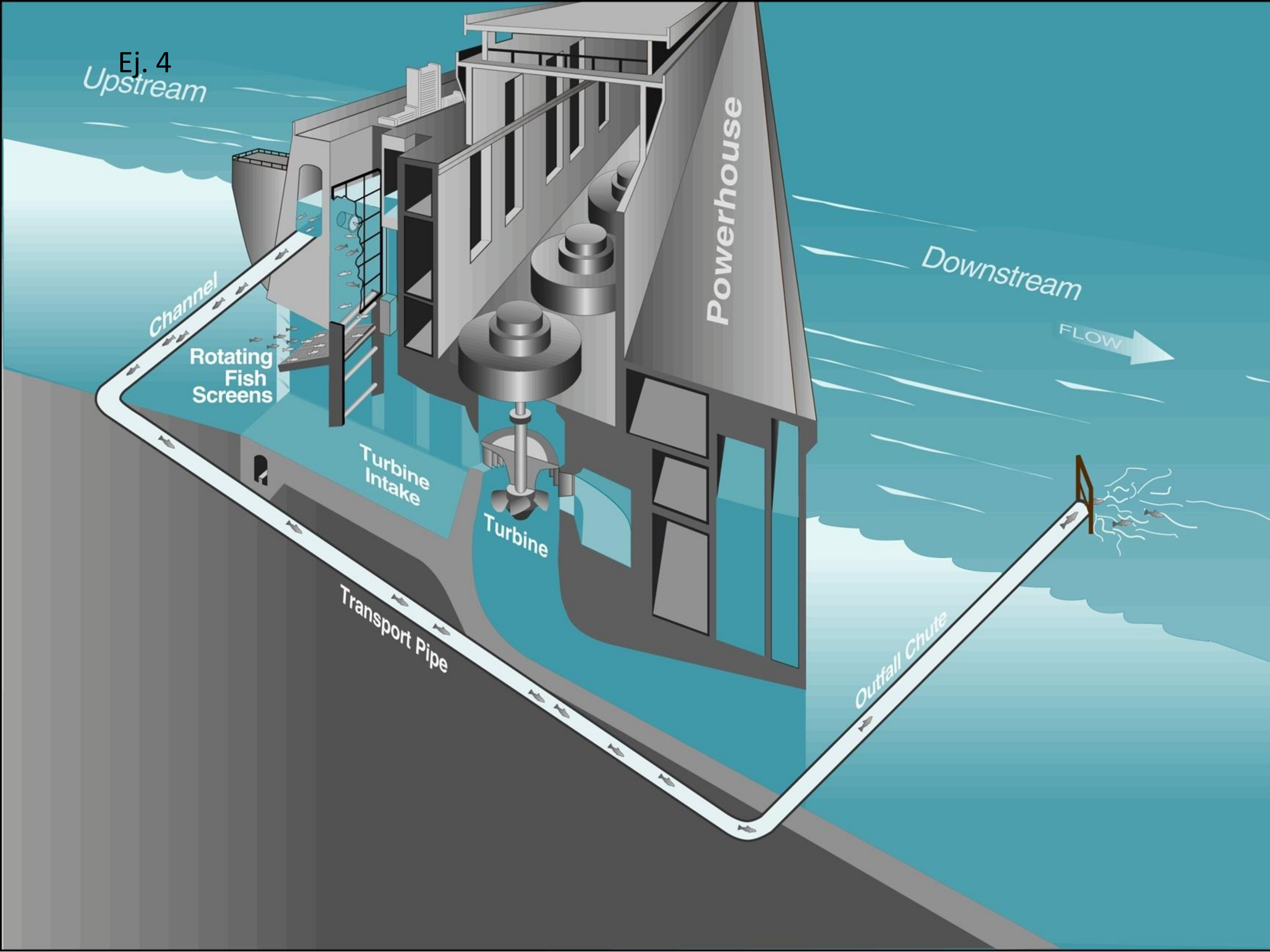
Ej. 4


Upstream
Powerhouse
Downstream
FLOW
Channel
Rotating Fish Screens
Turbine Intake
Turbine
Transport Pipe
Outfall Chute

Algunos ejemplos de sistemas de transporte de peces aplicables a embalses

https://www.youtube.com/watch?v=eGzdOpCisnQ

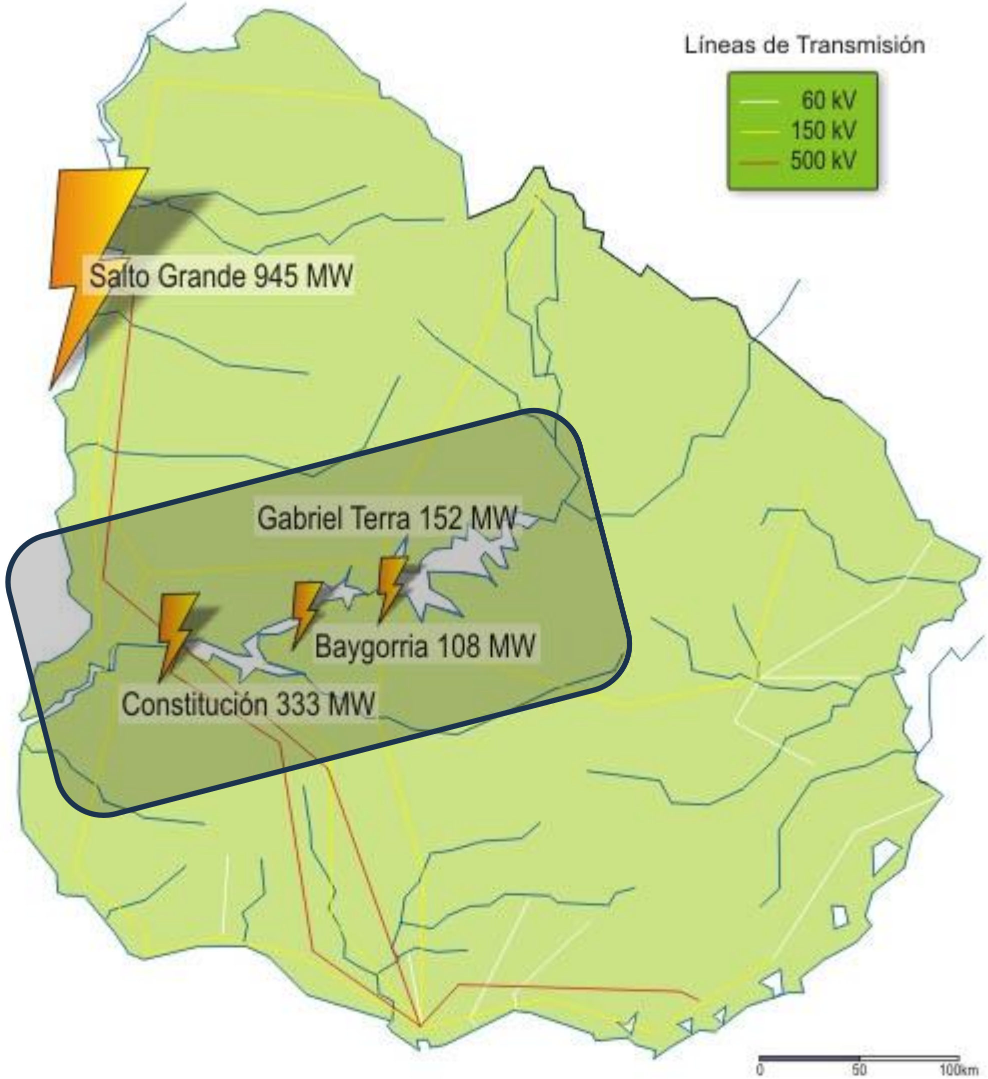
https://www.youtube.com/watch?v=1GaQDwamBwU

https://www.youtube.com/watch?v=nopg9JSTTzg

https://www.youtube.com/watch?v=2z3ZyGlqUkA

https://www.youtube.com/results?search_query=salmon+pump+upstream+bypass

https://www.youtube.com/results?search_query=whoosh+innovations



Centrales Hidroeléctricas

Capacidad Instalada y Líneas de Transmisión

Fuentes: Achkar (2000) y UTE

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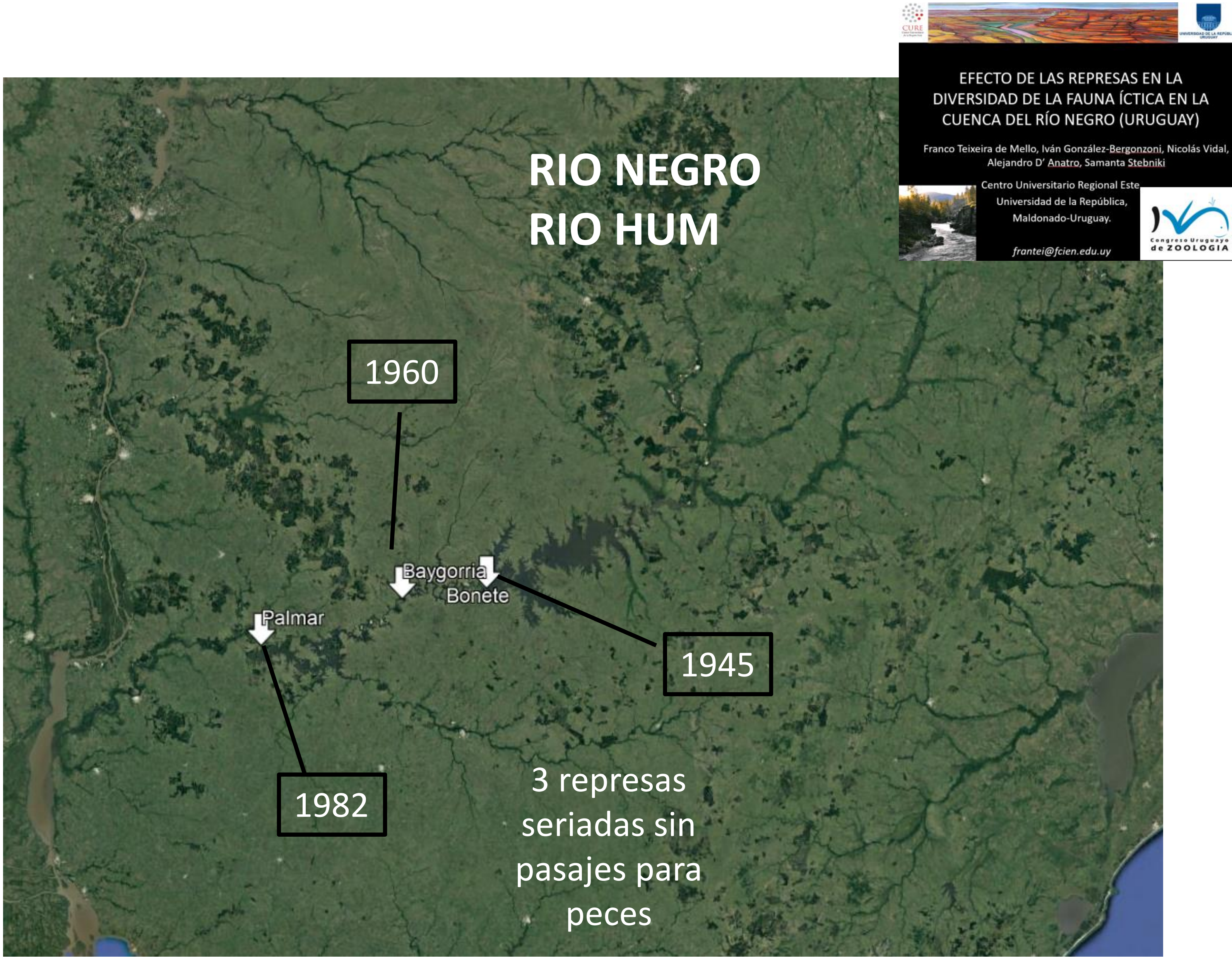
RIO NEGRO
RIO HUM
1960
Baygorria
Bonete
Palmar
1945
1982
3 represas seriadas sin pasajes para peces
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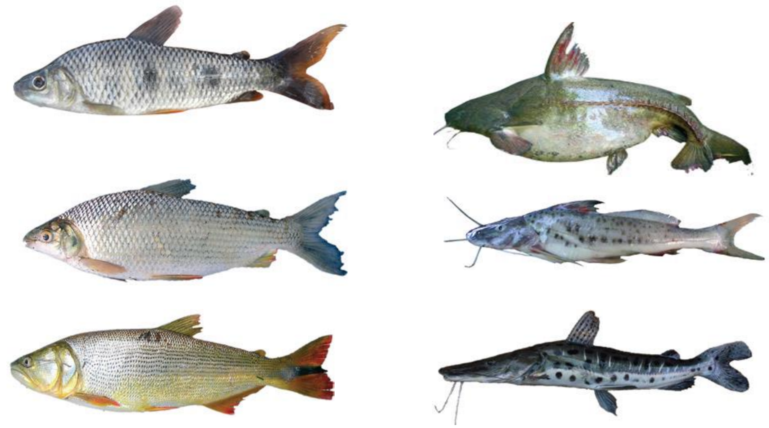
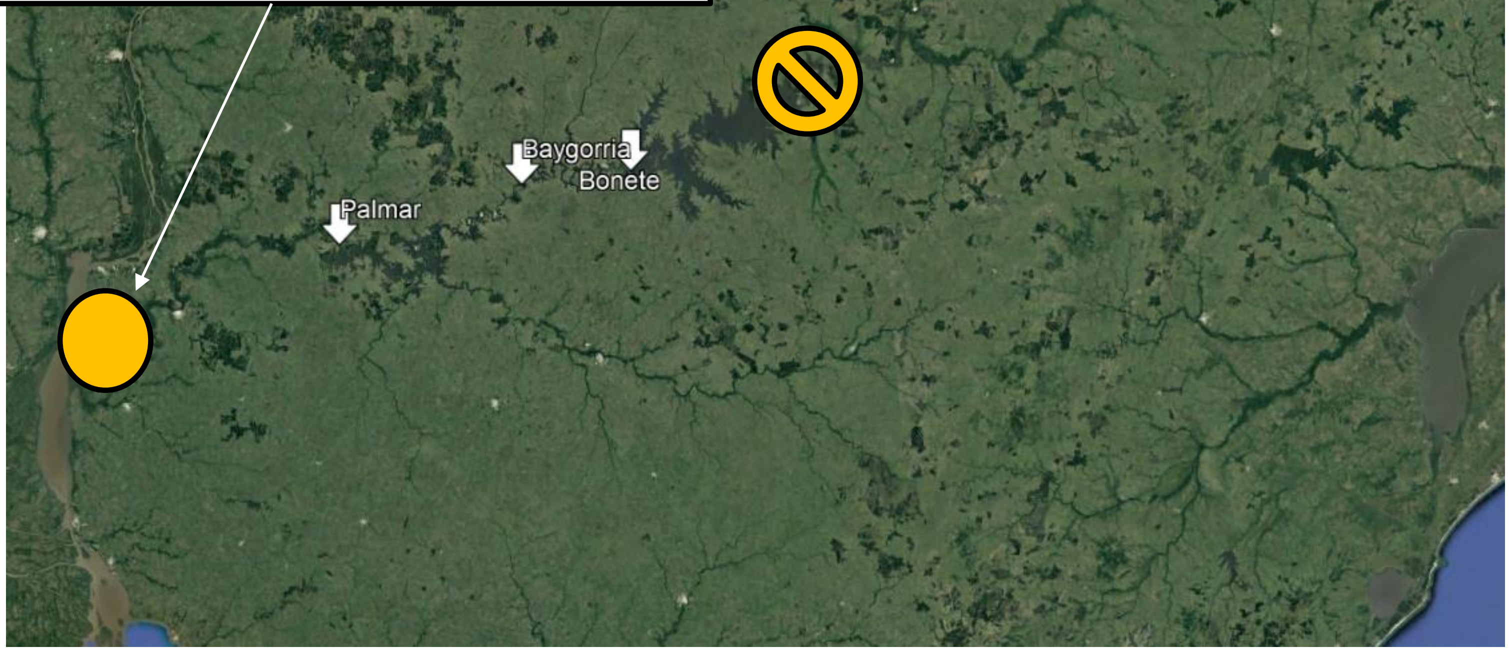
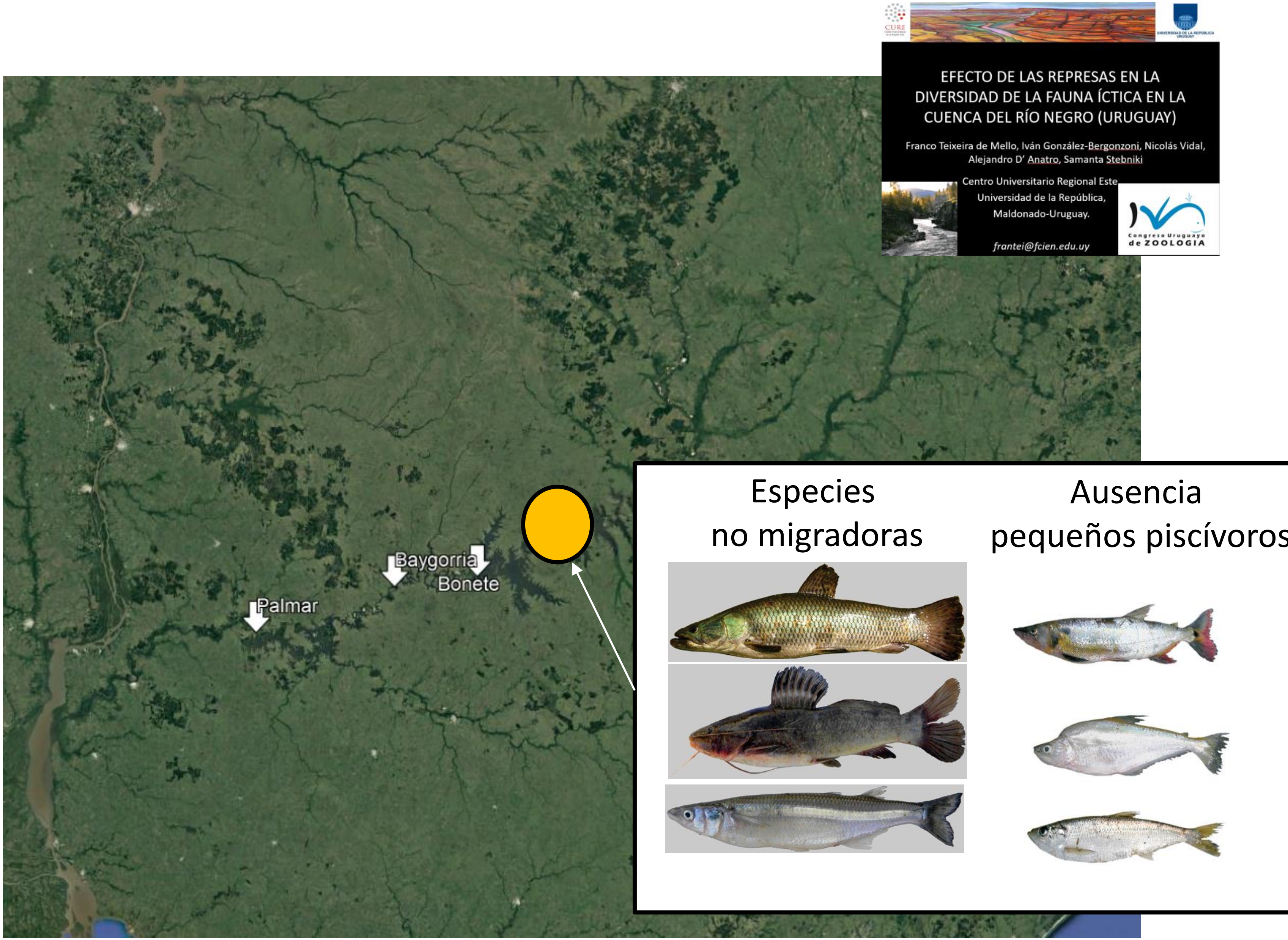
EFECTO DE LAS REPRESAS EN LA DIVERSIDAD DE LA FAUNA ÍCTICA EN LA CUENCA DEL RÍO NEGRO (URUGUAY)
Franco Teixeira de Mello, Iván González-Bergonzoni, Nicolás Vidal, Alejandro D' Anatro, Samanta Stebniki
Centro Universitario Regional Este
Universidad de la República,
Maldonado-Uruguay.
frantei@fcien.edu.uy
Congreso Uruguayo de ZOOLOGIA

Especies migradoras



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Congreso Uruguayo de ZOOLOGIA
Baygorria
Bonete
Palmar
Especies no migradoras
Ausencia pequeños piscívoros

La nueva agenda:

- Caudal ecológico o ambiental
- Eliminación de presas
- Fish migration

Decreto N° 368/018

APROBACION DE MEDIDAS PARA QUE LOS USOS DE LAS AGUAS PUBLICAS ASEGUREN EL CAUDAL QUE PERMITA LA PROTECCION DEL AMBIENTE Y CRITERIOS DE MANEJO AMBIENTALMENTE ADECUADOS DE LAS OBRAS HIDRAULICAS

Documento Actualizado

Promulgación: 05/11/2018

Publicación: 13/11/2018

El Registro Nacional de Leyes y Decretos del presente semestre aún no fue editado.

VISTO: la necesidad de establecer medidas para que los usos de las aguas públicas aseguren aquel caudal que permita la protección del ambiente y criterios de manejo ambientalmente adecuados de las obras hidráulicas;

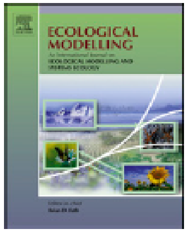
RESULTANDO: I) que el Estado debe promover tanto la conservación, como el aprovechamiento integral, simultáneo y sucesivo de las aguas, pudiendo disponer lo pertinente para la protección contra sus efectos nocivos, incluso los que puedan dañar el ambiente, de conformidad con lo que prevén los artículos 2° y 4° del Código de Aguas (Decreto-Ley N° 14.859, de 15 de diciembre de 1978);

Ecological Modelling 252 (2013) 266–272

Contents lists available at SciVerse ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel



Adapting the operation of two cascaded reservoirs for ecological flow requirement of a de-watered river channel due to diversion-type hydropower stations

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DOI: 10.1007/s002670010189

Undamming Rivers: A Review of the Ecological Impacts of Dam Removal

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ABSTRACT / Dam removal continues to garner attention as a potential river restoration tool. The increasing possibility of dam removal through the FERC relicensing process, as well as through federal and state agency actions, makes a critical examination of the ecological benefits and costs essential. This paper reviews the possible ecological impacts of dam removal using various case studies.

Restoration of an unregulated flow regime has resulted in increased biotic diversity through the enhancement of preferred spawning grounds or other habitat. By returning riverine conditions and sediment transport to formerly impounded areas, riffle/pool sequences, gravel, and cobble have reappeared, along with increases in biotic diversity. Fish passage has been another benefit of dam removal. However, the disappearance of the reservoir may also affect certain publicly desirable fisheries.

Short-term ecological impacts of dam removal include an increased sediment load that may cause suffocation and abrasion to various biota and habitats. However, several recorded dam removals have suggested that the increased sediment load caused by removal should be a short-term effect. Preremoval studies for contaminated sediment may be effective at controlling toxic release problems.

Although monitoring and dam removal studies are limited, a continued examination of the possible ecological impacts is important for quantifying the resistance and resilience of aquatic ecosystems. Dam removal, although controversial, is an important alternative for river restoration.

Dams are pervasive features of the world's river systems. There are more than 75,000 dams above 5 ft tall in the United States and 40,000 dams over 50 ft tall worldwide (National Research Council 1992, Dynesius and Nilsson 1994, McCully 1997). Smaller dams (i.e., below 5 ft tall) in the United States likely number in the thousands (American Rivers and NPS 1996). Nearly 80% of the total discharge of large rivers in the northern third of the world is impacted by river regulation (Dynesius and Nilsson 1994). This large number of dams worldwide can be attributed to the variety of services they provide: inexpensive and efficient power generation, effective flood control, navigation, water supply, irrigation, and recreational opportunities.

Nevertheless, the presence of dams is problematic for many aquatic ecosystems. Dams impact ecosystems in a number of ways: altering the natural cycle of flow, transforming the biological and physical characteristics of river channels and floodplains, and fragmenting the continuity of rivers (Petts 1984, Chisolm 1994, Yeager 1994, Ligon and others 1995, Ward and Stanford 1995, Stanford and others 1996, Poff and others 1997). Lateral exchanges of sediment, nutrients, and organisms between aquatic and terrestrial areas may be limited by fewer overbank floods in a dammed river (Junk and others 1989, Naiman and others 1993). Coastal areas may lose valuable habitat and shift biotic composition when they are deprived of sediment because of dammed rivers upstream (DOI 1996). The physical obstruction of both dams and reservoirs impedes and delays the migration of various organisms (Drinkwater and Frank 1994, Staggs and others 1995, Stanford and others 1996). The turbines of a hydropower operation harm fish and other biota as they attempt to pass (Dadswell 1996). The change from a river to a reservoir ecosystem often shifts species composition. Unnatural timing of flow releases for power production and the altered temperatures of those releases can confound emergence or growth cues (Petts 1984).

Recognition of these impacts has led to a search for solutions. For example, in the United States, the Federal Energy Regulatory Commission (FERC) relicensing process for hydropower operations is critically examining the environmental impacts of dams (American Rivers and NPS 1996). FERC issues 30- to 50-year licenses to dams owned by nonfederal entities, such as utility companies, municipalities, and independent

KEY WORDS: Dam removal; Restoration; Mitigation; Flow regime; Sediment; Fish passage

http://www.youtube.com/watch?v=4LxMHmw3Z-U

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- https://www.damremoval.eu/
- https://www.internationalrivers.org/campaigns/dam-removal
- https://worldfishmigrationfoundation.com/

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RESERVORIOS

Bibliografía recomendada

Thornton, J., A. Steel & W. Rast, 1996. Chapter 8. Reservoirs. In Chapman, D. (ed) Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring. 2nd. UNESCO/WHO/UNEP. http://www.who.int/water_sanitation_health/resourcesquality/wqachapter8.pdf

Y disponible en EVA

RESERVORIOS

(con foco en grandes embalses)

A° San Francisco, Minas