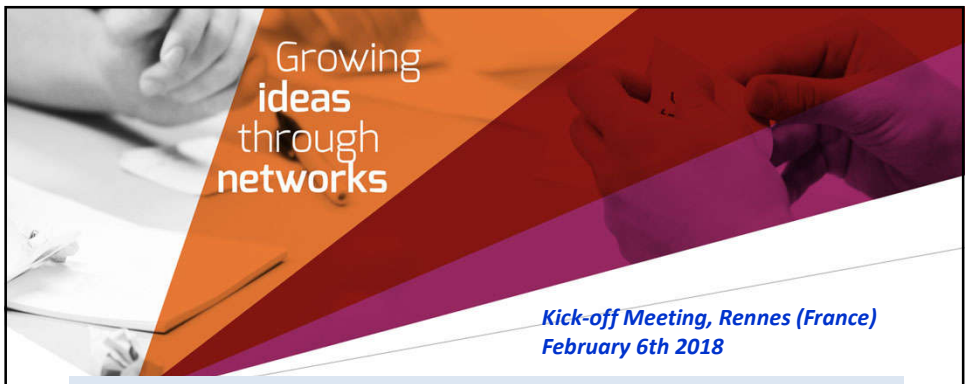

Kick-off Meeting, Rennes (France)
February 6th 2018

Riparian Vegetation Encroachment in Mediterranean Rivers

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Funded by the Horizon 2020 Framework Programme of the European Union COST **CONVERGES** (Action CA16208)

Riparian Vegetation Encroachment in Mediterranean Rivers

- The **encroachment of riparian vegetation** (ERV) is the invasion of the active channel by woody Riparian Vegetation.
- A widespread process in most of Mediterranean rivers.
- Main causes of ERV are linked to:
  - Flow regulation by Large **Dams** (great demand for water)
  - changes in **land use** (increase of forest cover in watersheds)
  - decrease of **extensive livestock**,
- Main consequences of ERV are:
  - Lateral **stabilization** of river channels, reducing their dynamism,
  - **Narrowing** of active channels
  - Degradation of aquatic habitats

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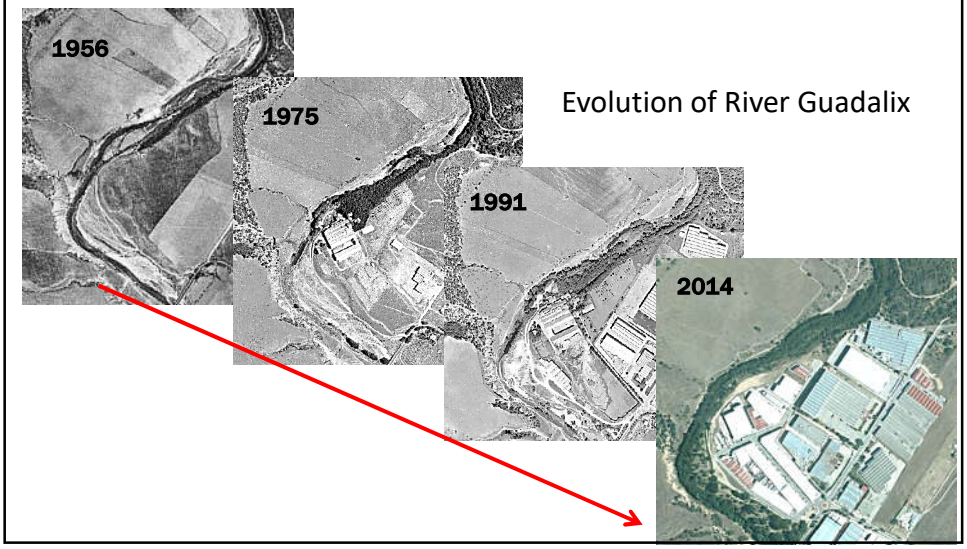
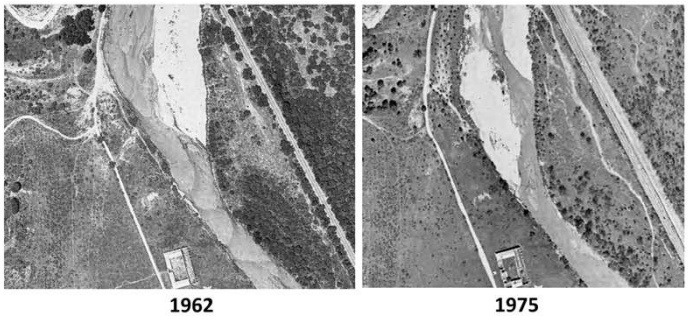
Riparian Vegetation Encroachment in Mediterranean Rivers



Evolution of River Guadalix

Río Guadarrama

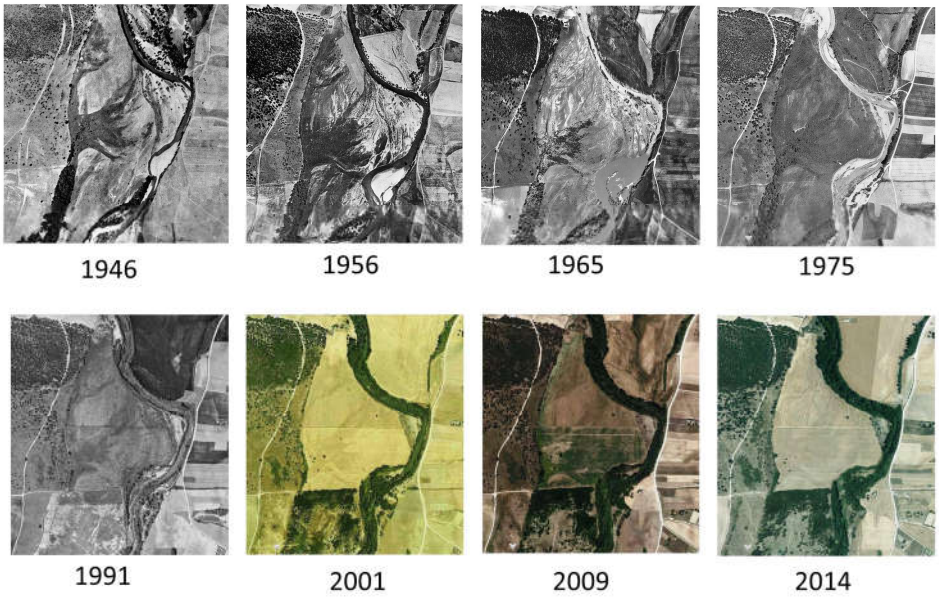

1962

1975


1999


2014

River Jarama



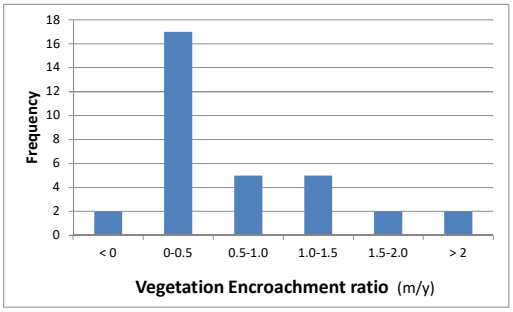
Riparian Vegetation Encroachment Ratios in rivers below large Dams

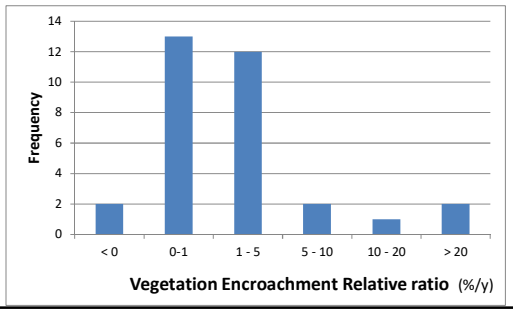
Quantification of Encroachment process: between years t_1 and t_2

- **Riparian Encroachment ratio** (REr): increase of riparian vegetation per year (*m/y*):
  - $REr = \frac{Veg.\,Area_2 - Veg.\,Area_1}{Channel\ Length\ .\ (t_2 - t_1)}$
- **Relative Riparian Encroachment ratio** **R**REr (*%/y*):
  - $RREr = 100.\ \frac{REr}{Veg.\,Area_1}$

ERV Ratios in rivers below large Dams

Reach	period year1	year 2	Vegetation Encr. Rat m/y	Veg. Encr. Rel. rat. %
Jarama 1a	1956	1975	0.27	0.61
Jarama 1b	1975	2014	0.80	1.63
Jarama 2a	1956	1975	2.54	2.17
Jarama 2b	1975	2014	0.41	0.25
Jarama 3a	1956	1975	-0.92	-2.09
Jarama 3b	1975	2014	0.46	1.75
Jarama 4a	1956	1975	2.05	2.45
Jarama 4b	1975	2015	0.44	0.36
Manzanares 1a	1956	1975	0.17	0.66
Manzanares 1b	1975	2014	0.67	2.36
Manzanares 2a	1956	1975	1.14	11.93
Manzanares 2b	1975	2014	1.30	4.17
Guadalix 1a	1956	1975	0.08	0.33
Guadalix 1b	1975	1991	0.07	4.47
Guadalix 1c	1991	2009	0.90	29.22
Guadalix 1d	2009	2014	0.30	1.47
Guadalix 2a	1956	1975	0.43	6.96
Guadalix 2b	1975	1991	0.03	0.13
Guadalix 2c	1991	2009	0.52	1.98
Guadalix 2d	2009	2014	0.07	0.22
Guadalix 3a	1956	1975	0.12	0.25
Guadalix 3b	1975	1991	0.16	6.17
Guadalix 3c	1991	2009	1.48	27.77
Guadalix 3d	2009	2014	0.05	0.15
Alberche 1a	1956	1973	-0.06	-0.04
Alberche 1b	1973	2014	0.32	0.21
Alberche 2a	1956	1973	1.47	3.01
Alberche 2b	1973	2014	0.97	0.89
Alberche 3a	1956	1973	2.00	2.29
Alberche 3b	1973	2014	1.23	0.73
Alberche 4a	1956	1973	1.90	3.38
Alberche 4b	1973	2014	0.20	0.15





Riparian Vegetation Encroachment Ratios in rivers below large Dams

Variables explaining Vegetation Encroachment (**Pearson coef.** >0.3)

Vegetation Encroachment ratio (m/y)	
Substrate size	-0.35
Channel Slope	-0.31
Mean Annual Flow (m3/s)	0.33
Bankfull Channel width (Ha/km)	0.36
Active Chanel (Ha/km)	0.36
Max Anual Flow (m3/s)	0.38
Potenctial Growth width (Ha/km)	0.39
Distance to dam (m)	0.40

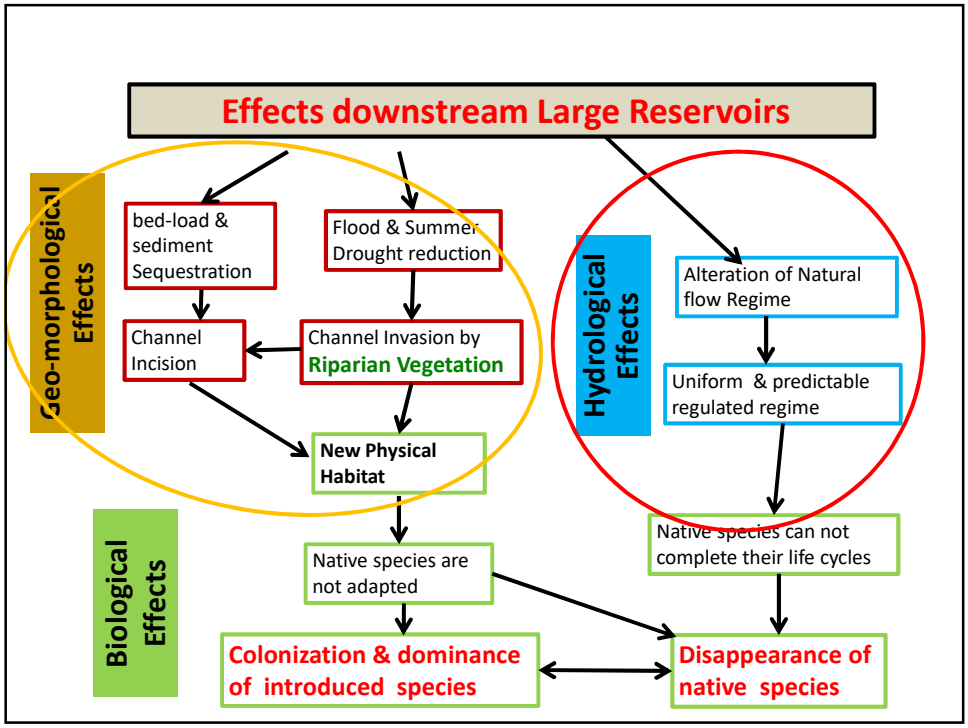
Vegetation Encroachment Relative ratio (%/y)	
Initial Vegetated Area (Ha/km)	-0.37
Natural Flow (m3/s)	-0.31
Bankfull Channel width (Ha/km)	-0.31
Potenctial Growth Index	0.31

- **Riparian Encroachment ratios** (REr) more correlated with:
  - \+ 'Distance to dam'
  - \+ channel available for being colonization
  - \+ Flow magnitude (Max Flow; Mean Flow)
  - – 'Substrate size'
  - – 'channel slope'
- **Relative Riparian Encroachment ratios** (RREr) more correlated with
  - \+ Available space index
  - – Initial Vegetated Area
  - – Natural Mean Annual Flow
  - – Channel Bankfull width

Riparian Vegetation Encroachment in Mediterranean Rivers

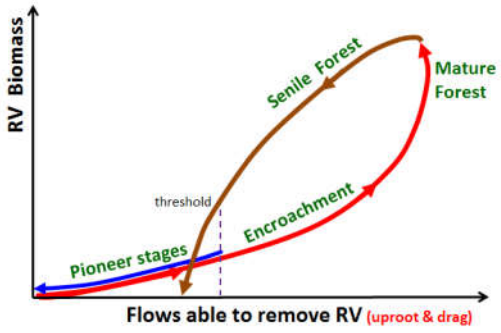
Effects of large Dams

- **Flood reduction** on magnitude and frequency
- Large Dams often used for **irrigation**. They reinforce RVE by releasing increased **summer flows**, which otherwise would limit vegetation growth.
- Once **installed and developed,** riparian vegetation increases riverbanks strength and inhibits their dynamics, promoting single-channel forms
- Vegetation Encroachment reduces bare areas preventing pioneer species recruitment, which leads to aged vegetation successional stages



Management of Riparian Vegetation Encroachment

- ERV reduces native biodiversity and thus, represents a **management problem difficult** to solve
- Unbalance between Vegetation growth capacity and its natural controls (Floods and Droughts)
- ERV is a **hysteresis** phenomenon
- Once **mature forest** stands are stablished, it is anchored by sediment accumulation and development of a dense root system.
- To reach a mature riparian forest takes 20 years, but to remove it by floods may take > 100 y.
- Setting Vegetation Flushing-flows is not enough.



CONCLUSIONS

- **Mature, dense and continuous Riparian Forests** without any recruitment are degraded ecosystems for most Mediterranean Rivers
- **High variability** of Riparian Encroachment ratios among regulated rivers
- **Higher absolute values** (REr) founded in **larger rivers**
- **Higher Relative values** (RREr) corresponding to **smaller river reaches**
- A **Conceptual Model** of Riparian Vegetation Encroachment Process is proposed, which must be validated across rivers
- **Proper River Management** must take into account RVE, for which further research is needed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Thank you for your attention