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Dahlia Greidinger International Symposium Spring 2023

Multiple Benefits of Riparian Ecosystem Restoration in Sustainable Agriculture

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Motivation for Research

- Israeli streams in agricultural basins often have highly degraded riparian ecosystems, with minimal functional vegetation, lacking trees.
- Anthropogenic changes have reduced the hydromorphological complexity of streams
- Lack of soil cohesion leading high rates of soil and streambank erosion
- Burial of streambed and damage to the aquatic habitat, reduced conveyance, increased flooding
- Strongly altered biotic communities, with loss of habitat for terrestrial and aquatic species, and native plant species

Nachal Tzipori- by Solelim

Contaminant transport
Field to stream

Mediterranean climate and agricultural practices result in a “first flush” transport of agricultural chemicals in early winter

Adverse Impacts:

- High sediment erosion from bare soil
- Export of dissolved and adsorbed chemicals, from farms to streams
- Degradation of water quality
- Ongoing soil loss and degradation
- Threatens long-term food production
- Destroys aquatic habitat and harms biotic life

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Pesticide, herbicides, fungicides and fertilizers applied all spring, summer and fall accumulate in soil

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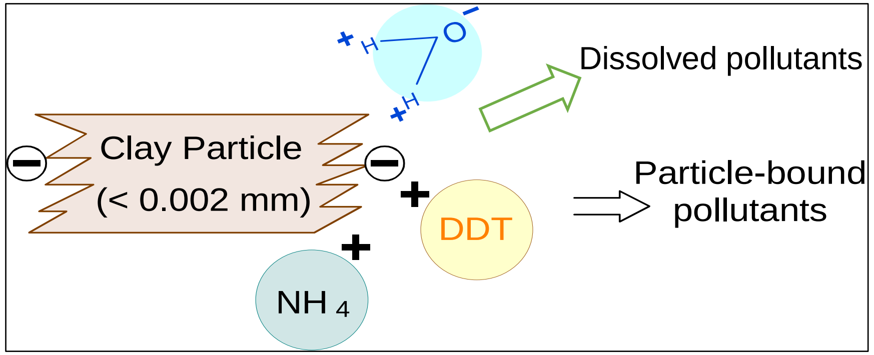
Rain splash impact on bare soils transports sediment and both adsorbed and dissolved chemicals from bare slopes



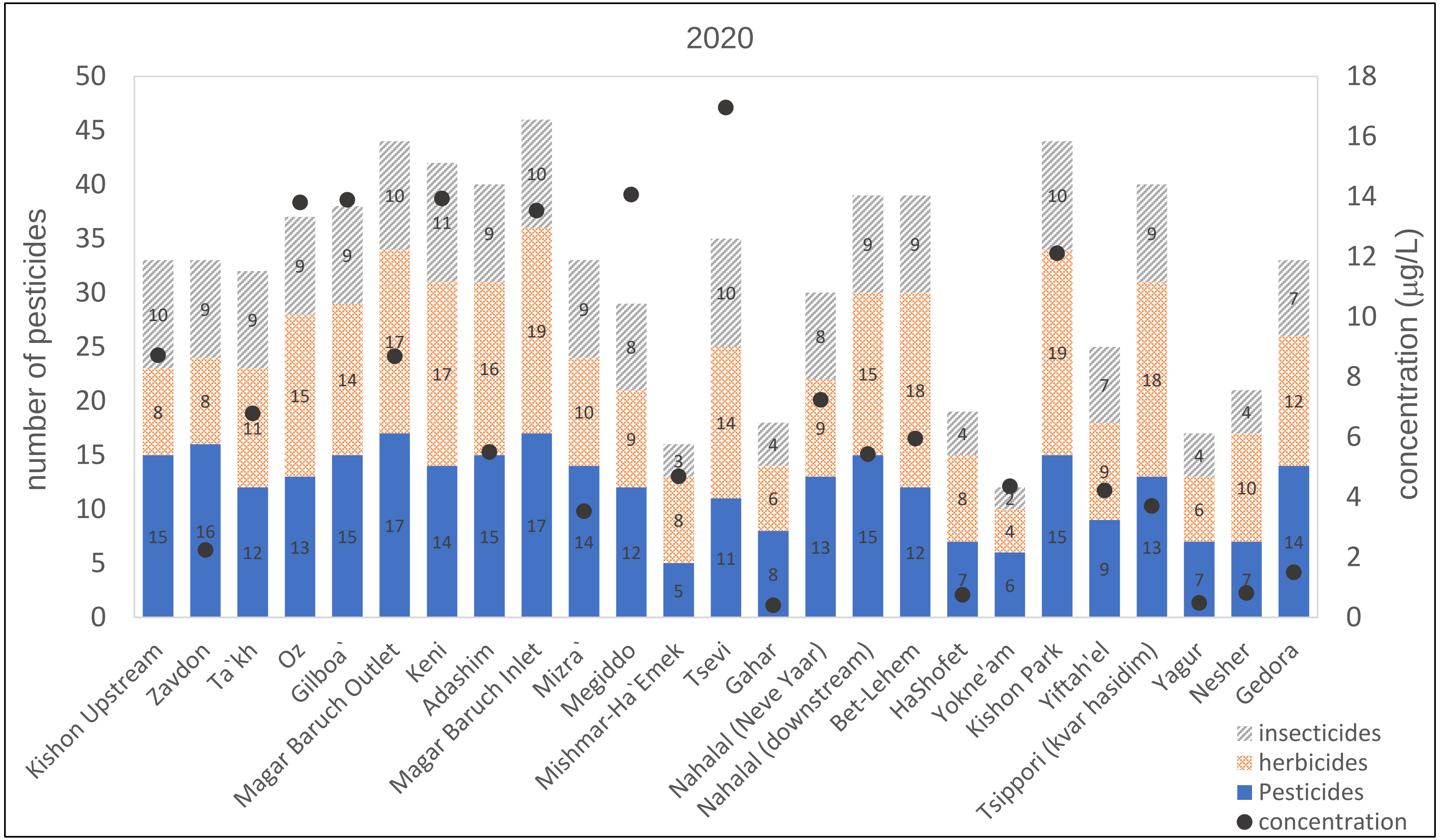
Soil Particle

Ag chemicals

Particulate-bound

Soluble

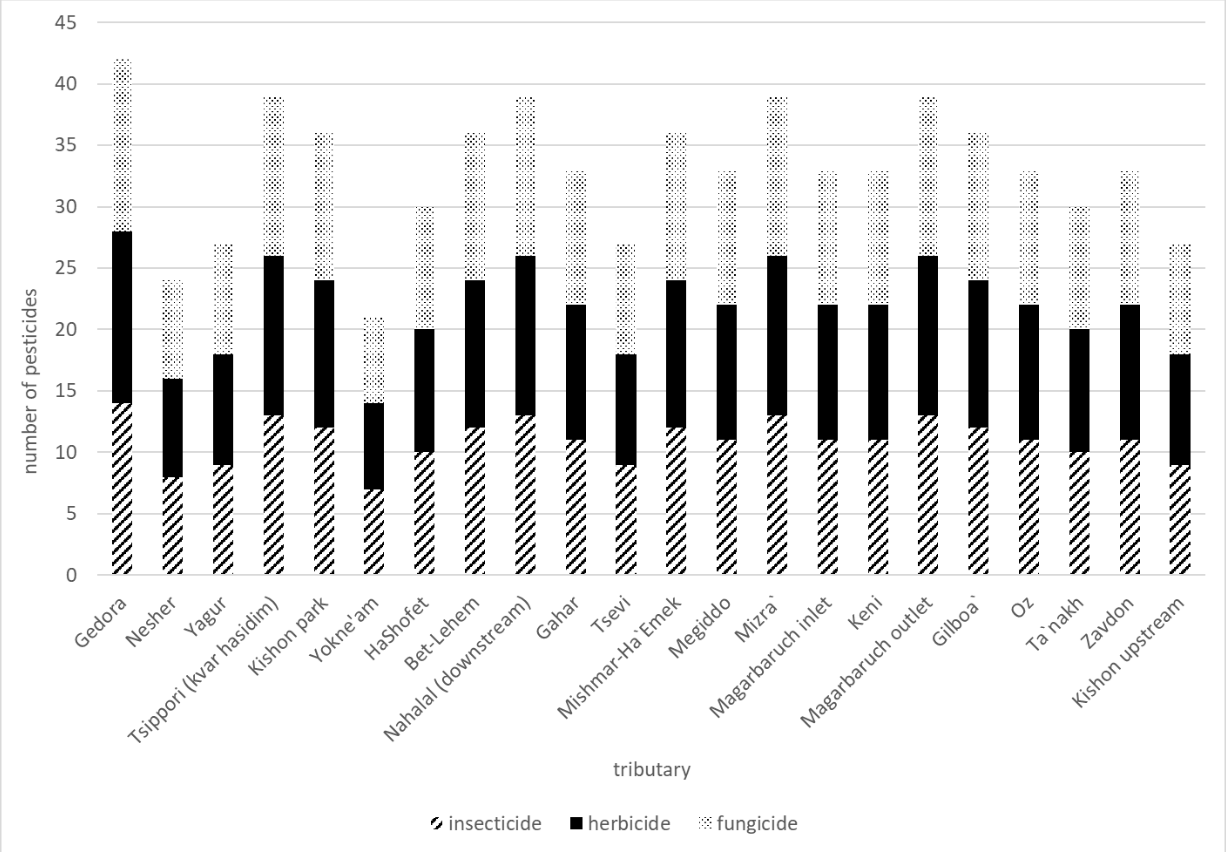
Distribution and Concentrations of **Dissolved** Pesticides in First Flush Storm Sampling Kishon Basin, December 16, 2020

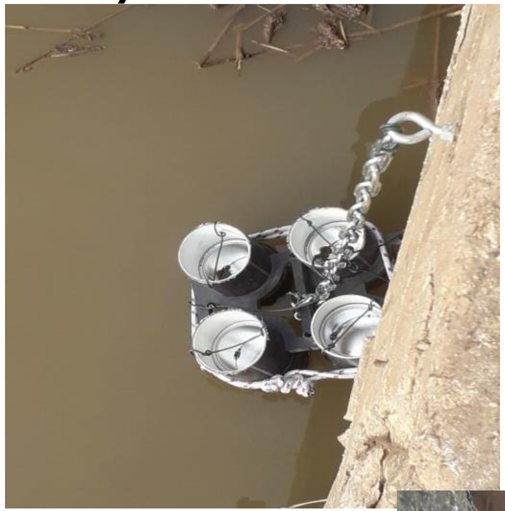


Type	#
Fungicides	20
Herbicides	24
Insecticides	12
Total	56

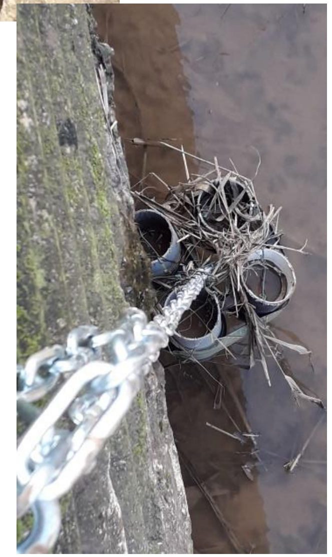
Funded by Chief Scientist, Israel Ministry of Agriculture

Distribution and Concentrations of **Adsorbed** Pesticides in First Flush Storm Sampling Kishon Basin, December 16, 2020





Type	#
Fungicides	21
Herbicides	17
Insecticides	11
Total	56



Now We know some of the problems

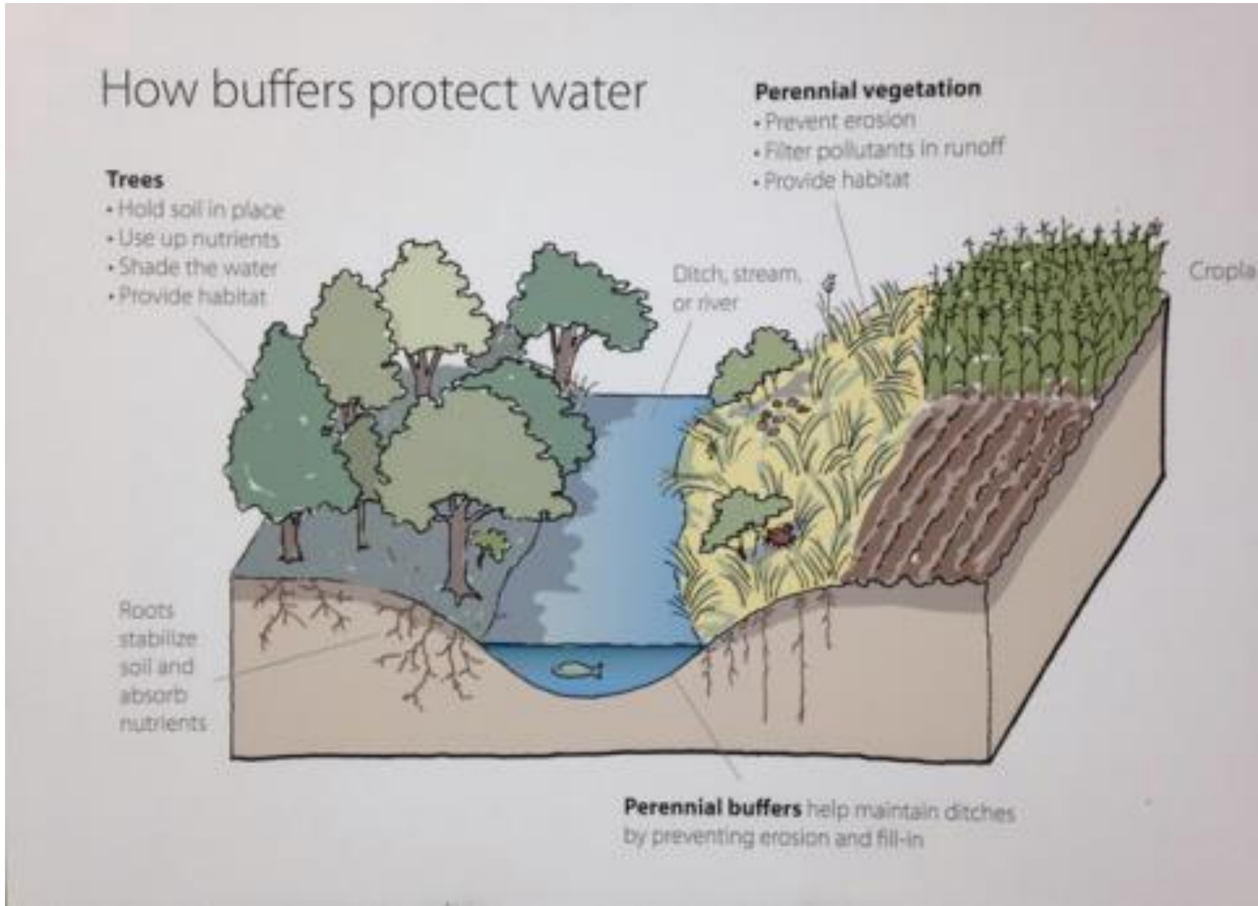
Research Goals

***** Restore Riparian Ecosystems
in Agricultural Basins, targeting source reduction, using strategic plant composition to meet management objectives

* Quantify Targeted Ecosystem Services (species & plot scale)

* Characterize processes underpinning the ES delivery

* Provide data needed for decision-makers to promote this as nature-based BMP on a national scale, as policy
ie. Netherlands example



Ecosystem Services Categories
(Riis et al, 2022)

1. Provisioning services: physical products directly obtained from riparian vegetation (e.g., timber, seeds, and harvestable genes

2. **Regulating and maintenance services**: those that both directly (e.g., pollutant capture, carbon sequestration) and indirectly (e.g., regulation of decomposition, climate, and hydrology) sustain environmental quality

3. Cultural services include tangible recreational uses (e.g., walking along a river) or less tangible benefits such as aesthetic and spiritual benefits and educational values

Ecosystem Services Targeted in Study

Improving water quality by-

- Filtering runoff/ uptake excess N (↑ nutrient cycling)
- Capturing sediment & adsorbed pollutants

Protecting water resources- ↑ gH2O recharge & flooding ↓

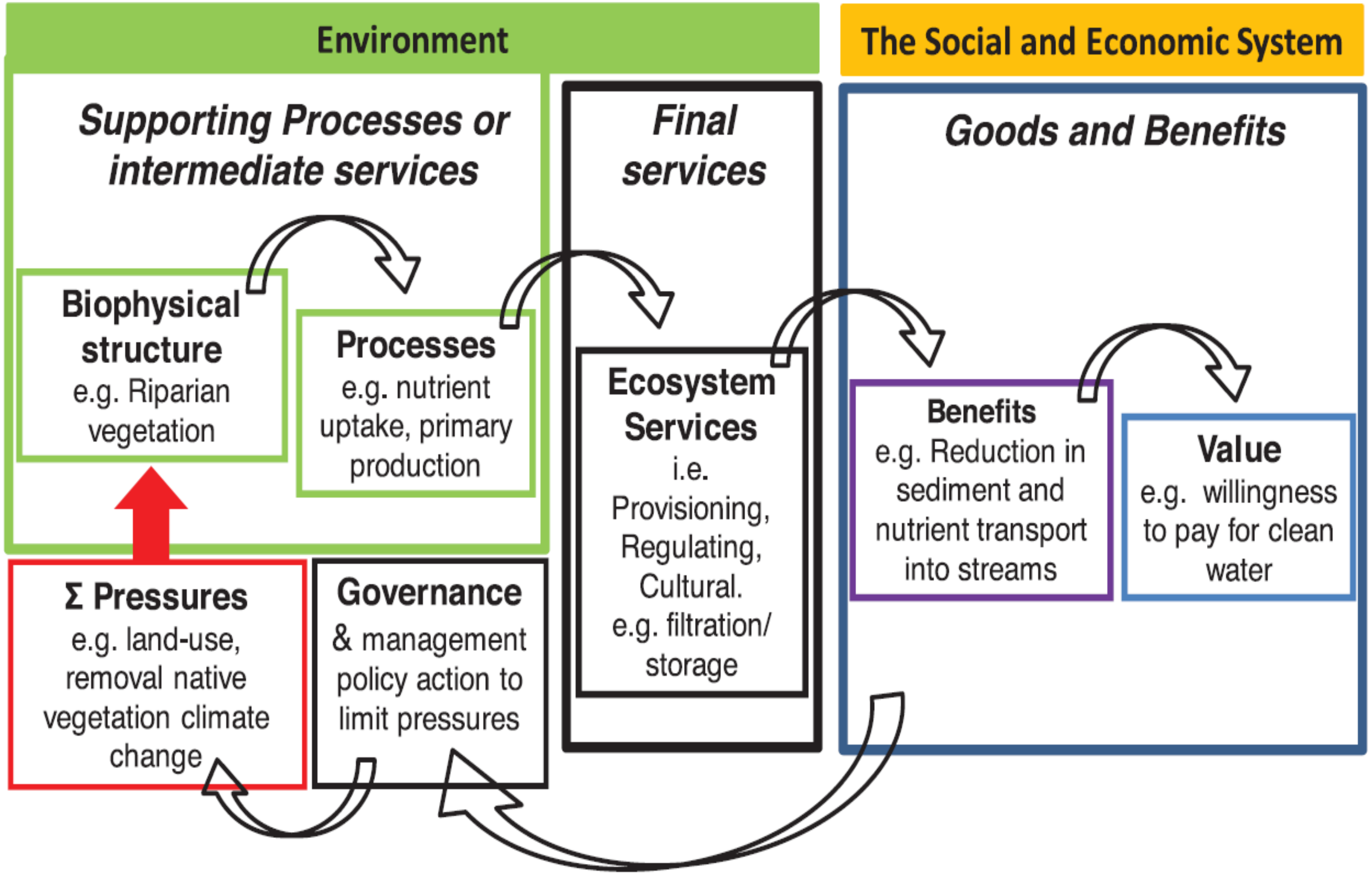
Protecting soil resources- ↓ soil erosion, ↑ soil cohesion

Improving biodiversity-

- Restoring native plant species
- Creating ecological habitat for aquatic

and terrestrial wildlife

Ecosystems cascade model: supporting processes and intermediate services in the delivery of final ecosystem services and benefits



Source: Adapted with permission from Potschin and Haines-Young (2011).

Functional Benefit of Restoring Riparian Ecosystems
Habitat Creation

- Demonstrated to improve ecological status of degraded streams (Kail et al., 2007).
- Creates a variety of pools=habitat heterogeneity (hiding places for fish).
- Increased instream biotopes (gravel and leaf litter); changed biotope proportions (decreasing % silt)
- Supports Mycorrhizal fungi (Amaranthus, 1996).
- Builds soil, adds organic matter, provides food source
- Provides habitat for terrestrial species (birds, reptiles, amphibians, small mammals.
- Significant increases in macroinvertebrate total density, total biomass, and taxon richness.

AQUATIC CONSERVATION

Marine and Freshwater Ecosystems

RESEARCH ARTICLE | Open Access

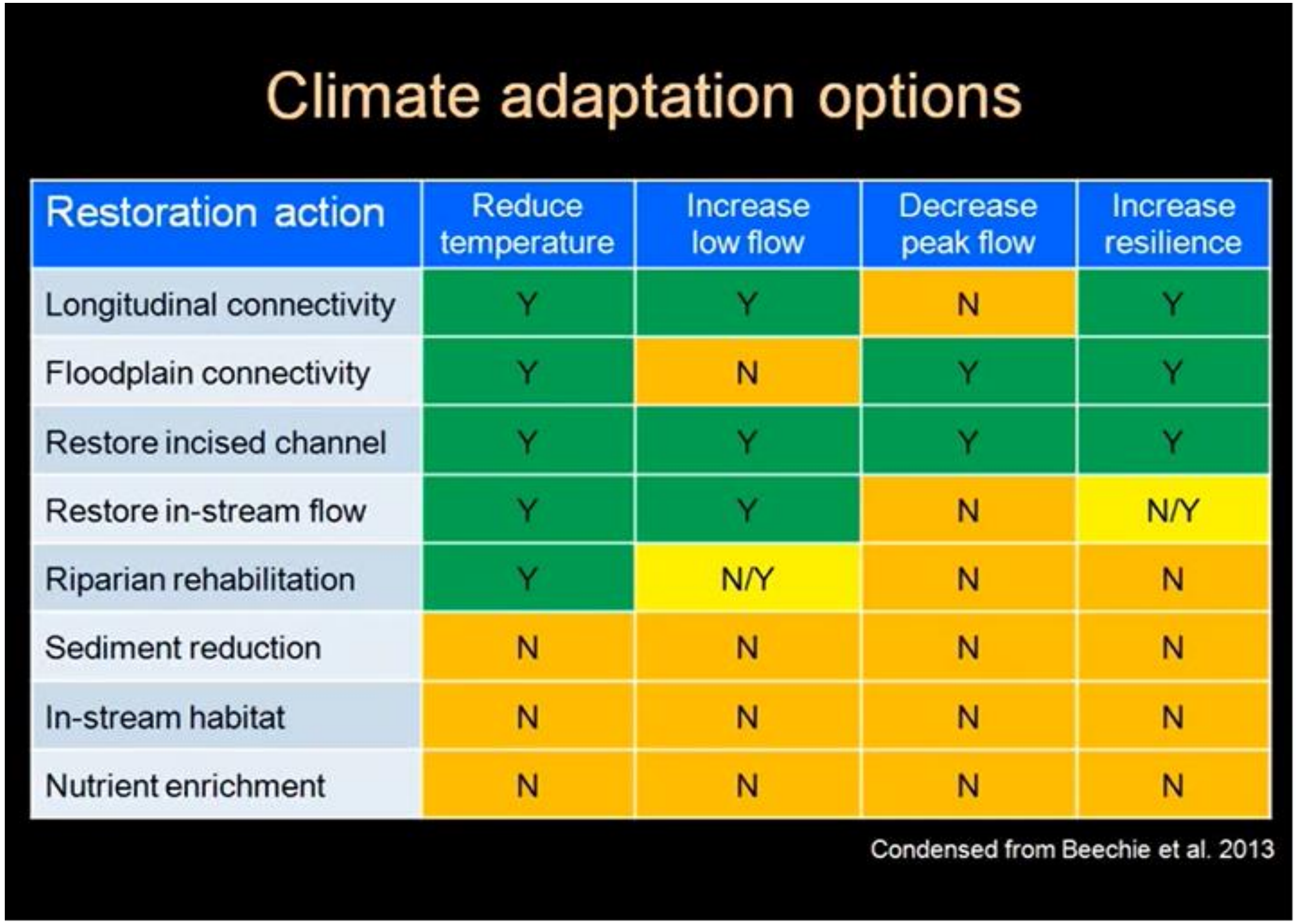
Adding large woody material into a headwater stream has immediate benefits for macroinvertebrate community structure and function

Ahmed Al-Zankana, Tom Matheson, David Harper

First published: 25 January 2021 | https://doi.org/10.1002/aqc.3529 | Citations: 1

Functional Benefit of Restoring Riparian Ecosystems
Climate Change Implications

- Reduces flood risk- provides flow resistance, adds hydrodynamic complexity, and increases infiltration capacity.
- Lowers stream water temperature (shade)- climate change may increase stream temperature, with adverse impacts to stream biota (ie. 2 degrees coral).
- Increases groundwater recharge- greater infiltration conserves water and reduces flooding.
- Enhances ecosystem resilience.



Climate adaptation options

Restoration action	Reduce temperature	Increase low flow	Decrease peak flow	Increase resilience
Longitudinal connectivity	Y	Y	N	Y
Floodplain connectivity	Y	N	Y	Y
Restore incised channel	Y	Y	Y	Y
Restore in-stream flow	Y	Y	N	N/Y
Riparian rehabilitation	Y	N/Y	N	N
Sediment reduction	N	N	N	N
In-stream habitat	N	N	N	N
Nutrient enrichment	N	N	N	N

Condensed from Beechie et al. 2013

Spatial Scale Compared to Benefits

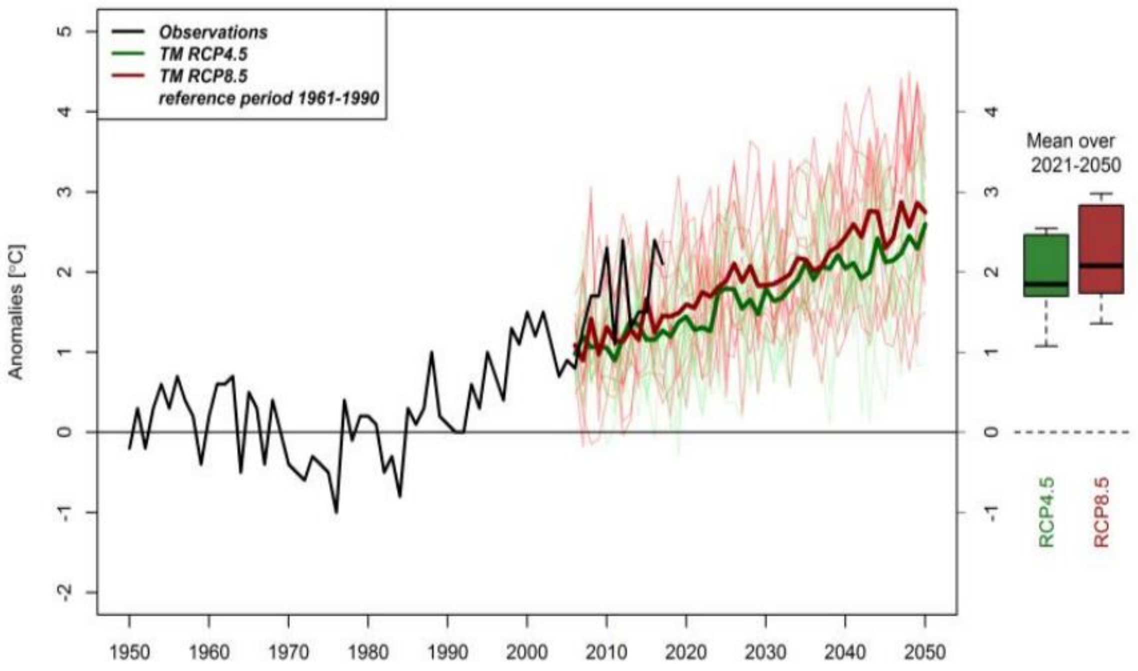
- Riparian vegetation has the capacity to deliver a disproportionately high amount of ES relative to their extent in the landscape (Sweeney and Newbold 2014)
- The spatial scale targeted for riparian ecosystem restoration along the stream provides unique benefits because of their ecotone characteristics, which improves overall ecological functions (Capon et al. 2013)

Courtesy of Dr. Roey Egozi-
Aerial Photo of Neve Yaar Riparian Restoraton Experimental Plots on Nachal Nahalal, January 2023

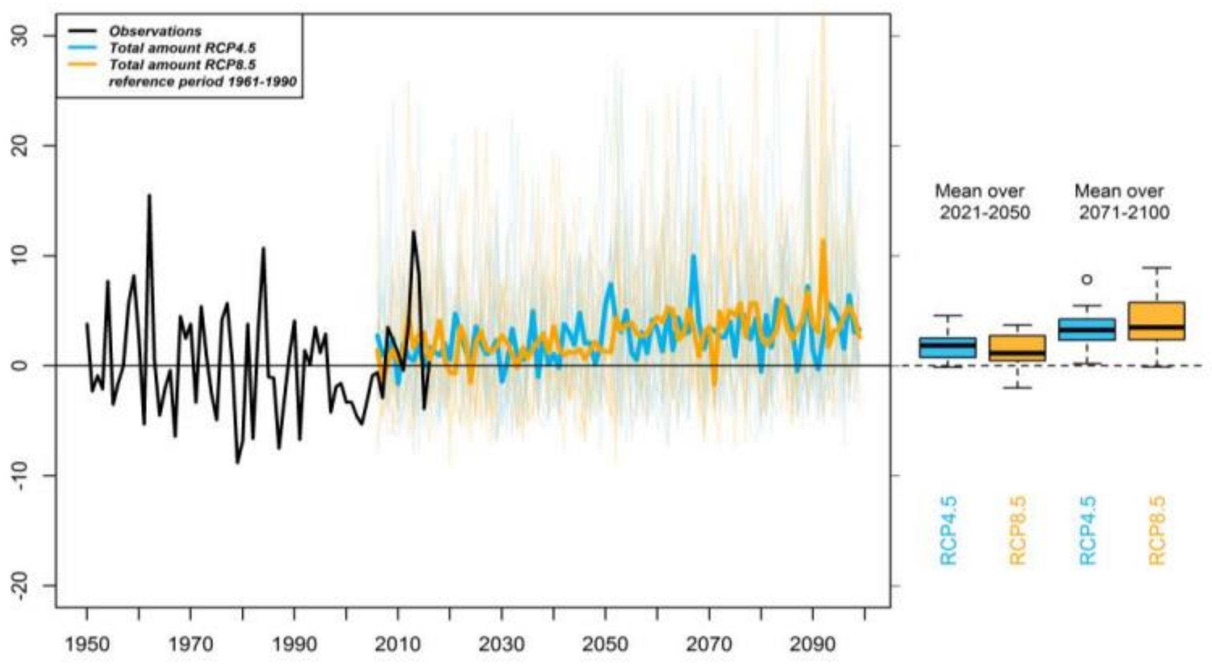
Riparian habitats & Climate changes in Israel

Riparian habitats are the most threatened areas in the Mediterranean region due to their vulnerability to climate change (Camarero, 2016)

Changes in summer average temp

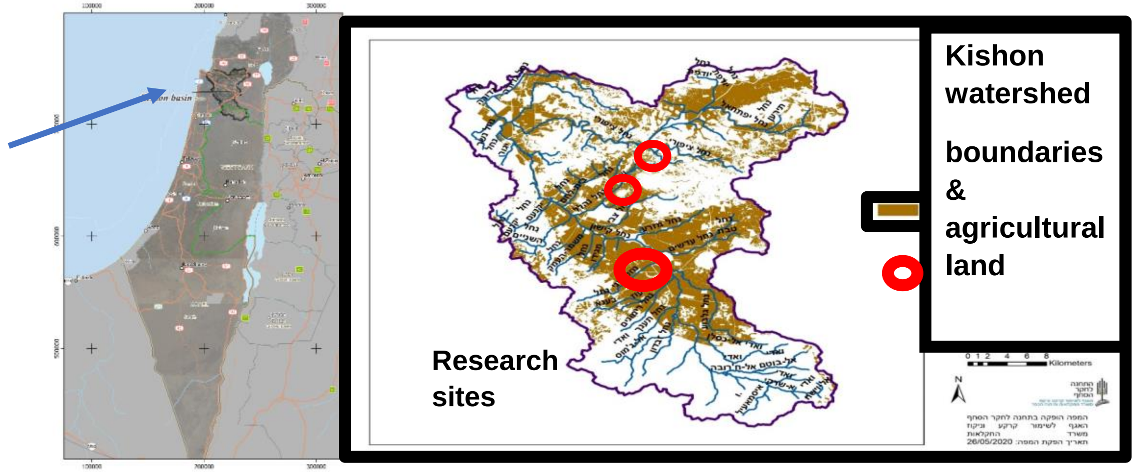


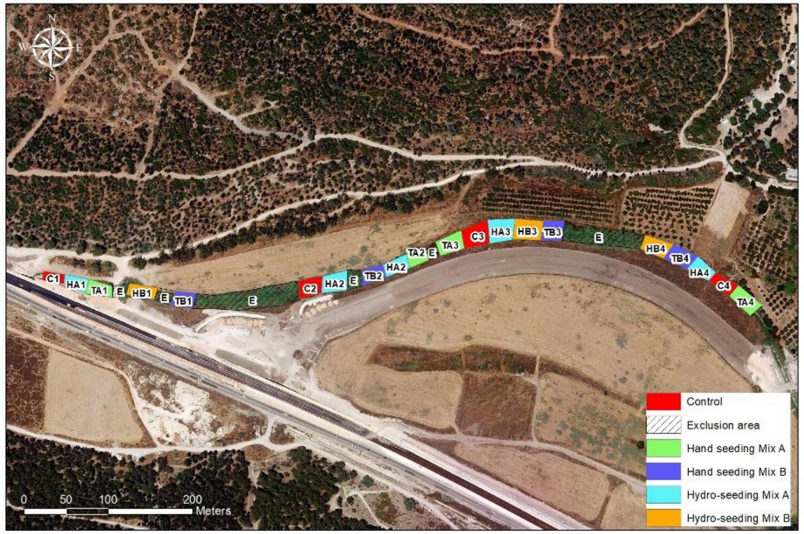
Duration of days without rain in winter-time



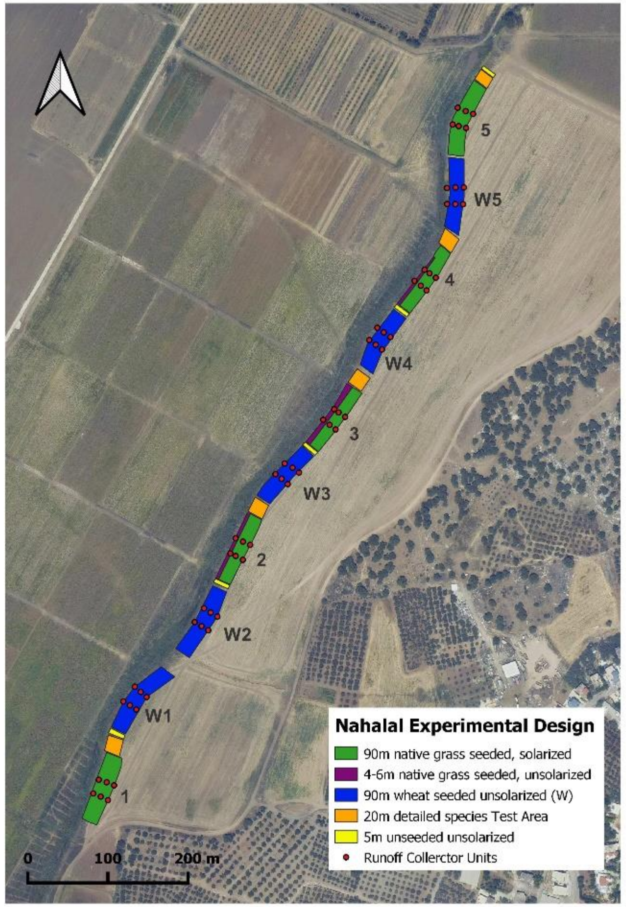
Climate change in Israel, past trends and predicted trends in the temperature and precipitation (Yosef et al. 2019)

3 Riparian Ecosystem Restoration Case Studies

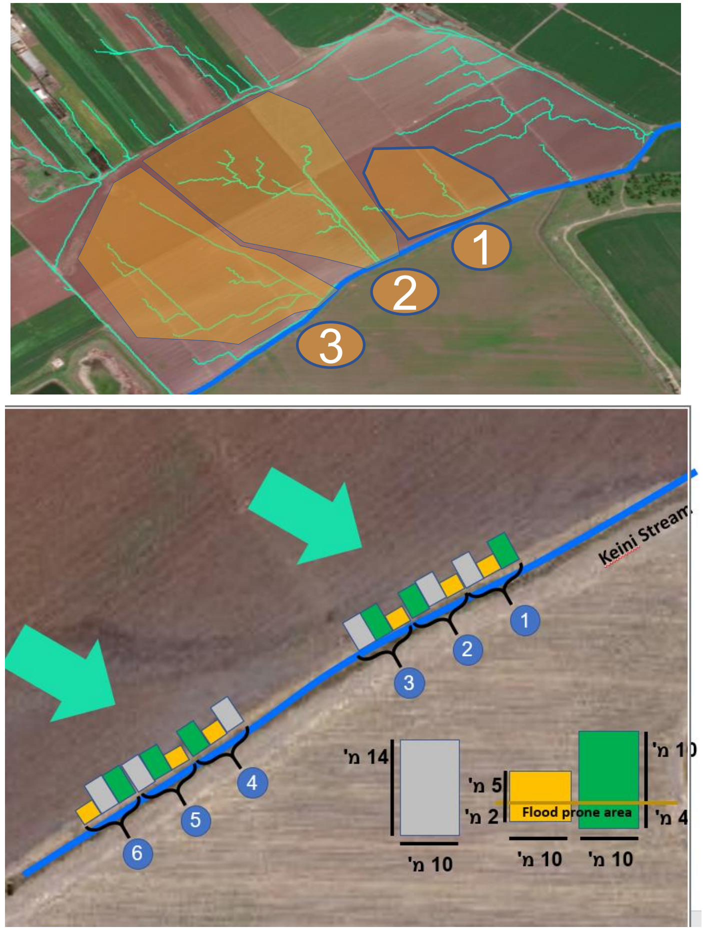




Nachal Tzipori 950 m



Nachal Nahalal 1 km



Nachal Keni 500 m

Case study: Keini stream

PhD researcher: Liron Israeli - School of Zoology, Tel Aviv University
Supervisors: Dr. Orah Moshe, Soill Erosion Research Station, Ministry of Agriculture
Prof. Dayan Tamar - The Steinhardt Museum of Natural History

Primary research objectives quantify: investigate hydrology, soil conservation, habitat creation

Flow accumulation direction

Keini Stream

MFRB Treatments

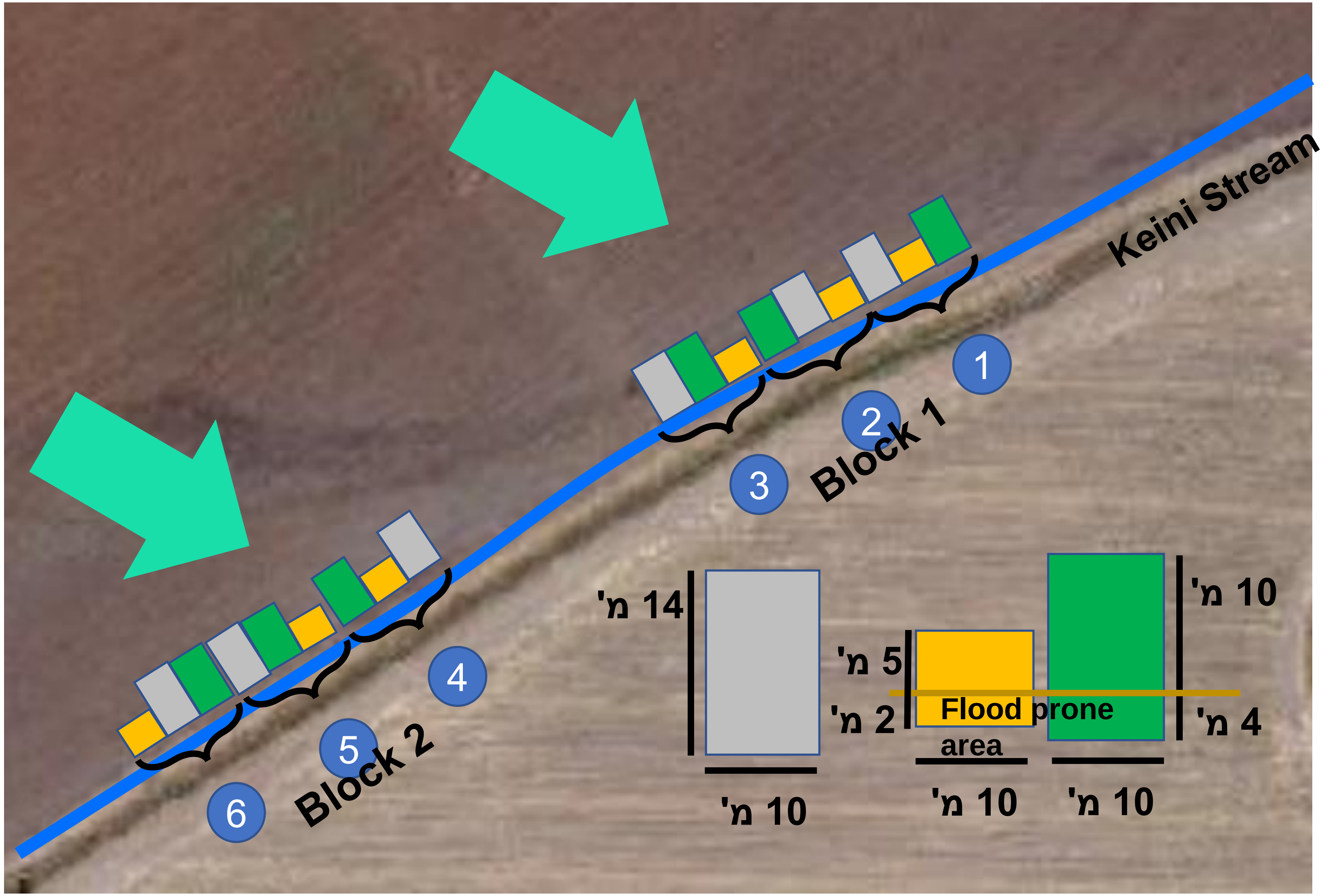
5-meter buffer treatment

10-meter buffer

treatment Control

2 Block number

Block= 3 replicates of 3 plots



Geomorphic Restoration - 4 stage channel design

Goals: Reconnecting floodplain, optimizing stream power to transport bed load and create habitat

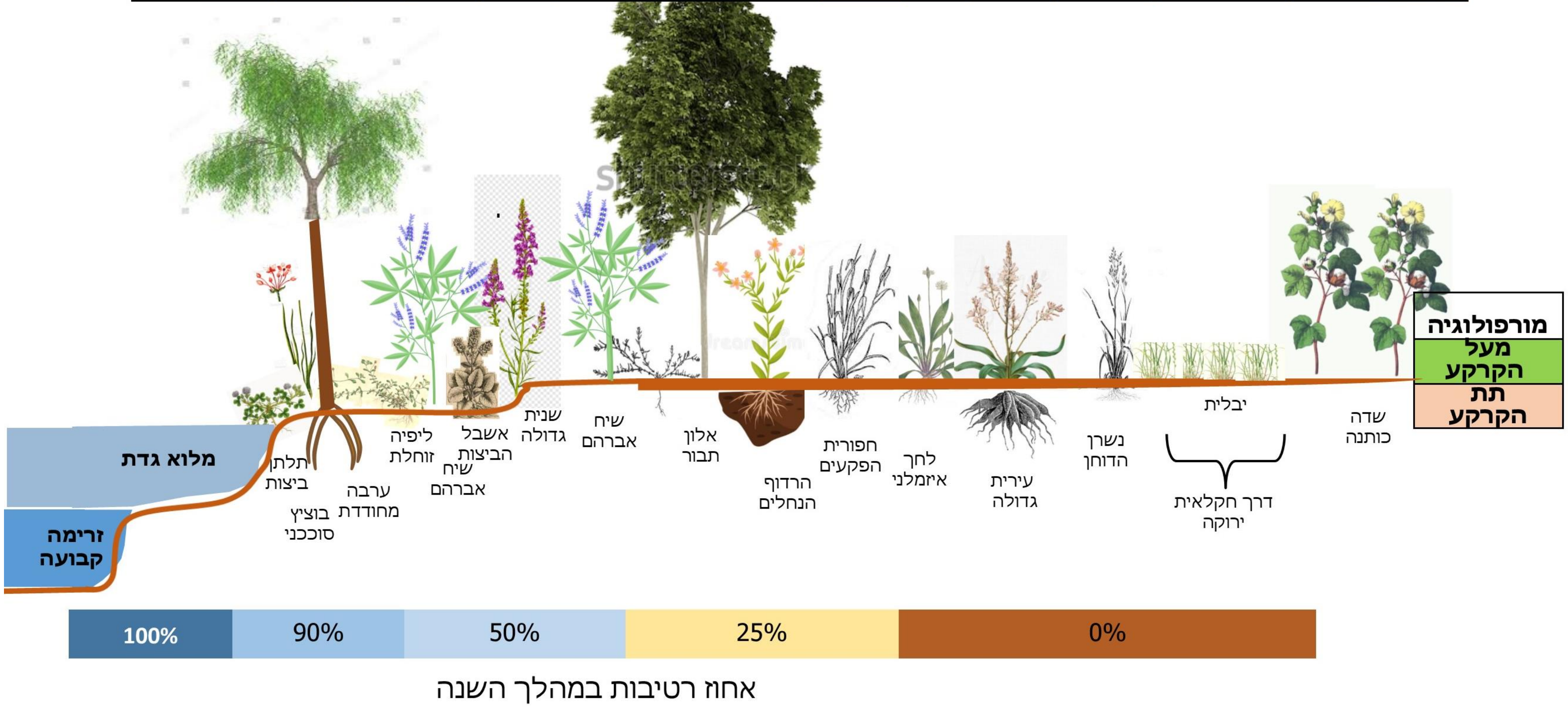
1) Base flow
2) Bank full
3) Flood-prone area
4) Flood plain area

Based on discharge data

Plant community design and microhabitat

- Ecosystem services
- Morphology
- Hydro period

שירותי מערכת	יבלית	נשרן הדוחן	עירית גדולה	לחך איזמלני	חפורית הפקעים	הרדוף הנחלים	אלון תבור	שיח אברהם	שנית גדולה	אשבל הביצות	ליפיה זוחלת	*ערבה מחודדת*	בוציץ סוככני	תלתן הביצות
הספקה														
האבקה														
בניית קרקע														
טיהור מים														



Case Study- Nachal Keni

Keini site before

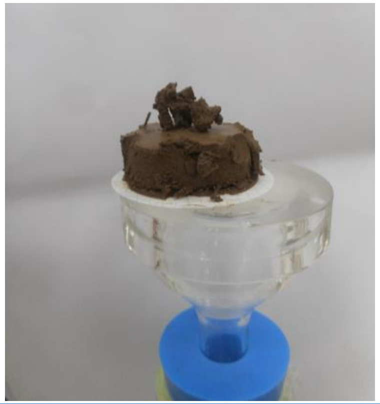
After targeted restoration

Measuring Sediment Capture

Economic Significance of Sediment Capture

Collection of Surface Runoff

Vacuum filtration



Quantify Soil Captured

Sediment Removal from Baruch Reservoir 2022

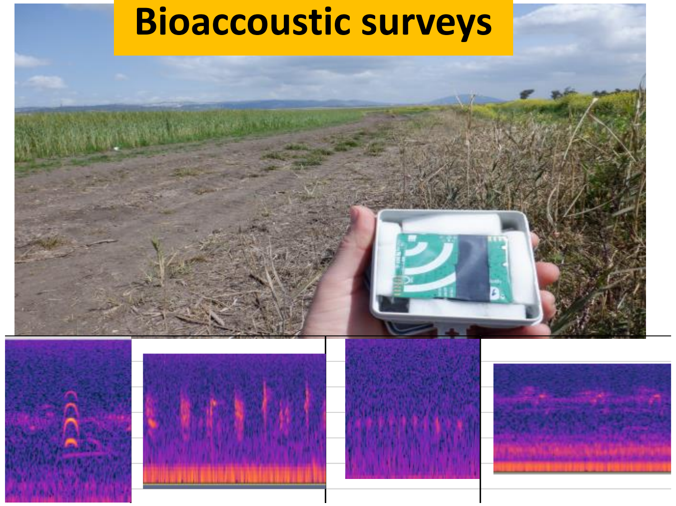
Measuring Biodiversity

Overview of monitoring completed

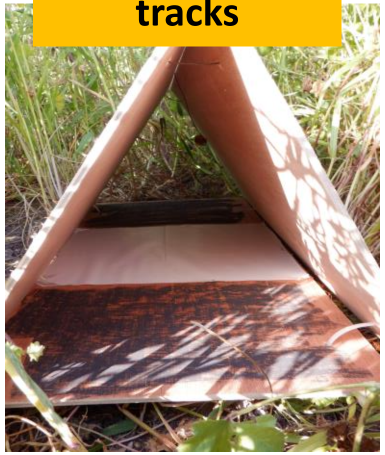
Ecosystem service	Performance indicator	Sampling methods	Sampling time
Regulation: Pest & beneficial	Abundance & diversity of pest populations	Visual count according to field inspection protocol	Once a week in season
	Abundance and diversity of main natural enemies	Visual count according to field inspection protocol	Once a week in season

Measuring Biodiversity

Bioaccoustic surveys



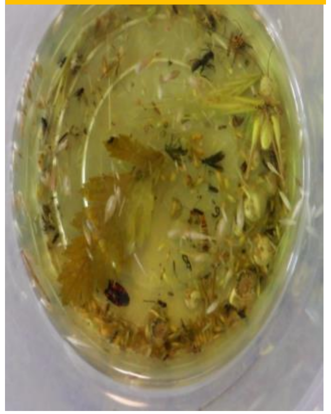
tracks



Soil Moisture Measurements

Changes in stream channel morphology

Pests and beneficials



Plant Debris Captured

Soil characteristics

Site characteristics – evaluating a range of ecosystem services

ID			Water quality of field to stream discharge						Soil qualities								Plant qualities							
Block	Treatment	Type*	TSS		P Total		N Ammonia		OM **	SI***	Soil moisture						Plant cover		Plant height		Plant diversity		Plant richness	
			Sum mg/l	Sum mg/l	Sum mg/l	Sum mg/l	Sum mg/l	Sum mg/l	%	Kfs cm/s	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm	%	%	m'	m'	Units	Units	Units	Units
			2021	2022	2021	2022	2021	2022	2020	2022	Feb. 2022	Feb. 2022	Mar. 2022	Mar. 2022	Apr. 2022	Apr. 2022	2021	2022	2021	2022	2021	2022	**2021**	**2022**
A	1	L	7,986.3	30,550.0	0.3	8.2	0.1	0.0	1.32	0.01	95.70	90.70	49.65	49.40	32.55	42.55	98	100	107.0	80.0	9.6	9.33	23.00	66.17
A	2	S	13,581.0	2,700.6	0.5	0.4	2.2	6.0	1.24	0.00	90.10	95.10	48.70	48.75	28.70	34.00	91	100	57.3	80.0	8.0	9.33	19.83	66.17
A	3	C	0.0	39,977.7	0.0	0.4	0.0	4.6	1.24	0.01	66.70	95.30	49.55	42.60	29.25	50.55	0	0	0.0	0.0	0.0	0.00	0.00	0.00
A	4	S	0.0	0.0	0.0	0.0	0.0	0.0	1.09	0.01	96.40	91.70	49.35	49.30	21.95	39.00	100	100	62.9	84.1	7.6	7.17	20.33	58.17
A	5	C	1,012.5	67,838.3	0.7	0.7	1.6	5.1	1.14	0.00	98.50	98.90	51.00	48.70	27.15	52.10	0	0	0.00	0.0	0.0	0.00	0.00	0.00
A	6	L	2,526.9	4,186.9	0.4	0.8	0.3	11.3	1.16	0.01	95.00	93.20	48.90	48.50	23.20	37.40	89	100	11.1	95.1	6.8	7.50	15.17	56.00
A	7	S	785.7	3,475.0	0.2	1.5	0.1	0.0	1.27	0.00	93.10	94.80	49.25	50.10	22.30	26.80	88	100	0.9	106.5	6.5	7.17	13.67	41.00
A	8	L	1,118.8	1,570.6	0.3	0.8	0.1	5.8	1.11	0.02	88.60	91.60	48.60	48.95	26.60	38.00	67	100	0.6	117.1	5.8	8.00	9.67	61.83
A	9	C	8,519.1	111,187.9	0.3	1.1	0.4	7.8	1.83	0.01	62.30	98.00	50.35	49.30	24.95	49.25	0	0	0.0	0.00	0.0	0.00	0.00	0.00
B	10	C	1,542.2	65,305.4	0.3	2.2	5.2	8.3	2.53	0.00	70.10	93.30	49.90	47.60	29.00	53.25	0	0	0.0	0.00	0.0	0.00	0.00	0.00
B	11	S	140,076.0	63.5	0.2	0.8	1.6	1.3	3.36	0.01	90.30	99.30	49.20	44.60	21.65	30.95	48	100	0.6	106.1	7.0	9.00	14.50	49.67
B	12	L	0.0	39,474.8	0.0	0.2	0.0	0.9	4.28	1.49	89.30	94.60	44.00	41.75	24.80	34.85	86	100	0.7	98.3	7.0	7.33	12.40	41.17
B	13	S	1,451.2	1,311.4	0.5	2.3	3.8	2.3	1.32	0.00	74.60	95.30	48.25	47.45	24.25	39.45	95	100	0.6	97.6	7.0	6.50	10.50	30.67
B	14	L	2,811.7	93.8	0.3	0.3	4.4	2.5	1.37	0.00	80.70	95.20	49.55	41.30	25.15	34.55	84	98	0.6	108.3	7.0	7.67	11.83	37.83
B	15	C	1,111.7	72,647.7	0.2	0.7	2.4	4.9	1.34	0.00	79.90	95.40	49.70	34.50	24.45	51.10	0	0	0.0	0.00	0.0	0.00	0.00	0.00
B	16	L	0.0	2,958.3	0.0	0.2	0.0	7.1	1.15	0.00	44.40	97.40	49.85	40.20	23.75	29.20	100	94	1.2	107.3	7.0	9.00	13.17	44.50
B	17	C	0.0	22,552.8	0.0	0.8	0.0	5.6	1.22	0.00	65.10	82.90	49.25	34.20	21.85	52.05	0	0	0.0	0.0	0.0	0.00	0.00	0.00
B	18	S	0.0	65.4	0.0	0.2	0.0	1.3	1.30	0.01	40.30	98.90	47.80	40.90	28.55	44.70	100	100	1.5	92.0	7.3	6.83	16.33	37.67

Going Forward: Nuts and Bolts

Required Components for Restoring Riparian Ecosystems

- Land Use Change: Defining targeted “room for the river” on a site by site basis
- Developing compensation program for farmers for releasing marginal land alongside streams- ideally permanent land use change without damaging farmers rights and benefits
- Restoring functional hydrogeomorphic characteristics (e.g., returning to a natural hydrologic regime based on 1.5-2 year flood recurrence intervals (fluvial geomorphologic processes)
- Conducting active plant introduction to restore native plant species and habitat, and maintaining the vegetation as needed through an annual vegetation management program (funded annually)
- Floodplain conversion- redefine land uses in (landscape) enables optimizing flood reduction benefits
- Provide ongoing invasive species and grazing control (funded annually)
- Restore hydrologic regime by releasing spring and stormwaters from reservoirs and providing alternative water sources

Gonzlez et al. 2015.

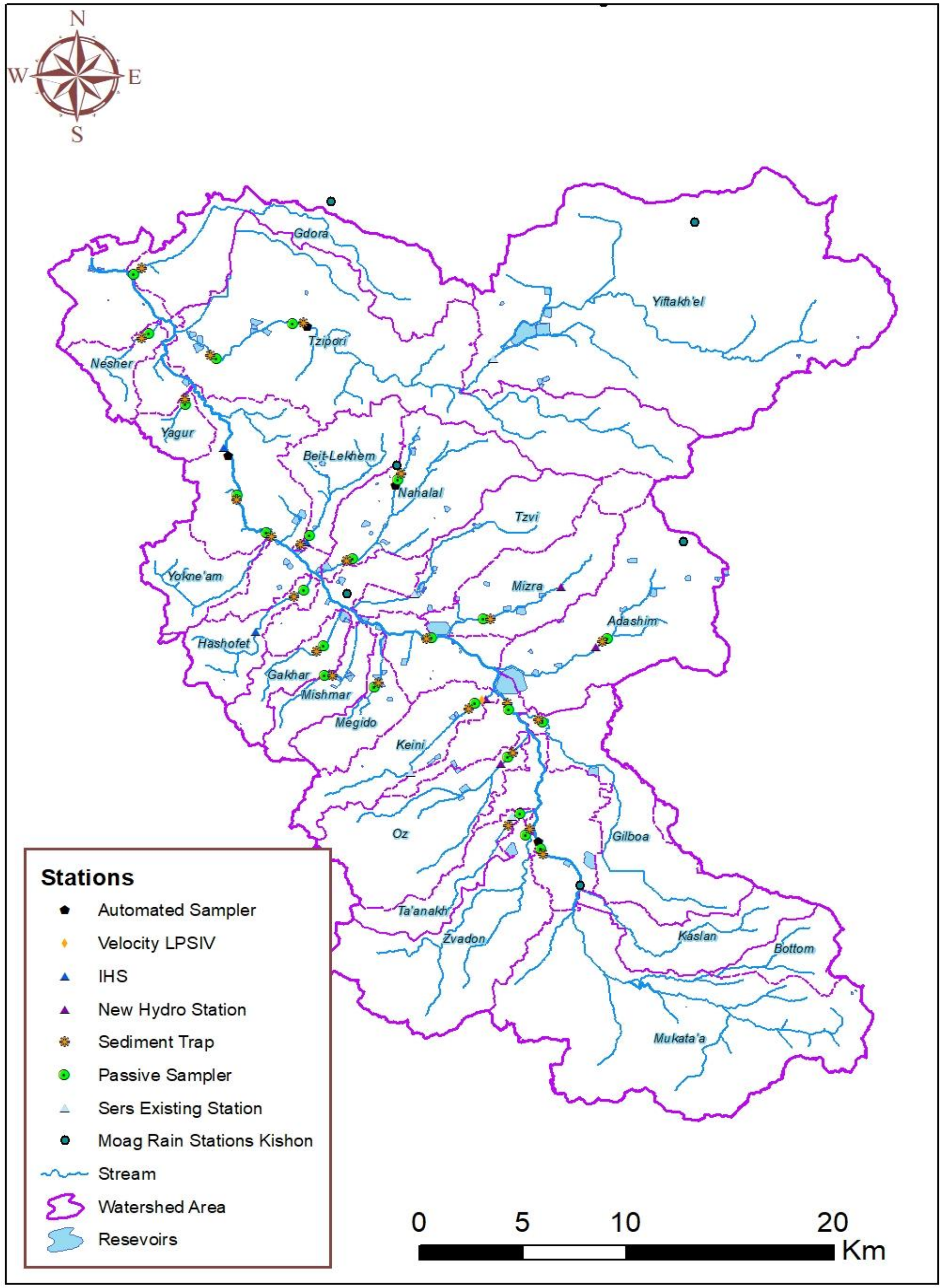
Future Research

- Test riparian ecosystem restoration in different soil types
- Expand ecosystem services to include soil biodiversity
- Develop management guidelines
- Create user-friendly app for decision-makers, facilitating implementation by farmers, municipalities and agencies

Thank you for listening

Questions?

Orahmo@moag.gov.il



Kishon Watershed Investigation Aimed to Identify "Hotspots" or Priorities for Restoration

25 Monitoring Stations

- Downstream in19 Tributaries
- 4 in Kishon Main Stream: Up, Down & 2 Midstream (in/ out Baruch Reservoir)
- Analyzed stream water and captured sediments for nutrients, pesticides, pharmaceuticals and metals

Funded by Chief Scientist, Israel Ministry of Agriculture