Restoration of Mediterranean dry grasslands in photovoltaic power stations – the effect of solar panels

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Energetic transition towards **renewable energies** results in **new challenges** for environmentally sound management including ecological restoration of degraded ecosystems.

In the framework of an **interdisciplinary project (PIESO)** aiming at **an ecological integration of photovoltaic park (PK)**, approaches to **restore plant biodiversity and soil function** were analysed on a calcareous Mediterranean site.

Solar panels change the microclimate modifying the **processes** involved in **plant succession** [1] following ecological restoration measures

We address the following major research questions:

- Do solar panels affect plant performance and restoration?
- Which restoration techniques facilitate the re-establishment of natural plant communities and do not compromise energy production ?

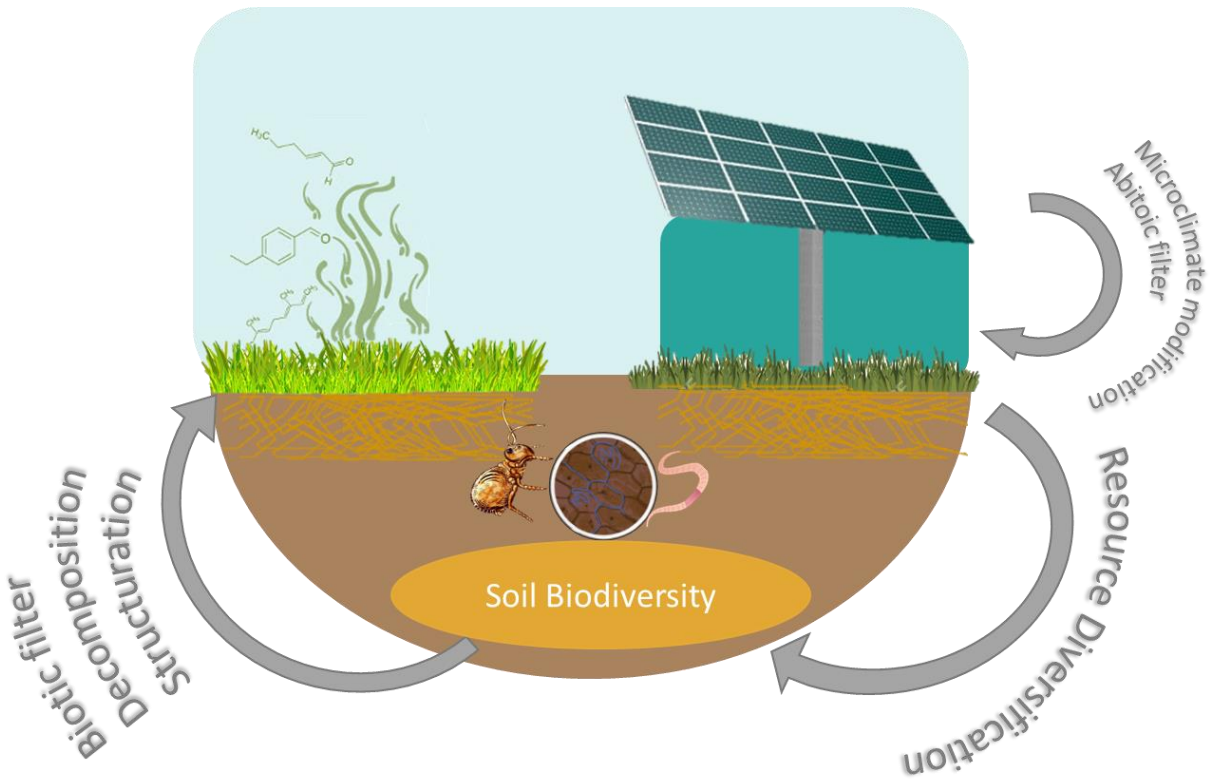

Fig.1: Plant soil network modification under Photovoltaic park

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We tested the effect of 4 restoration techniques on soil and vegetation:

1. Tillage
2. Tillage + hay transfer from an adjacent reference community (Brachypodium retusum grassland)
3. Tillage + monospecific sowing of B. restusum
4. Tillage + addition of vermicompost amendment and an untreated control.

All treatments were established under solar panels and outside.

Fig.2 : Restoration techniques

- Altogether the design comprised 40 plots of 4 m².
  - The experiment was set up in March 2016 at the PK of Roquefort-des-Corbières (France)
  - The experimental design included the restoration treatments as a fully randomised split-plot factor and solar panel as a whole-plot factor replicated in 5 blocks.

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1. ***B. retusum* survival was recorded** in 10 plants of **the hay transfer treatment**

2. Flavonoid, anthocyanin, nitrogen balance and chlorophyll index of *Brachypodium retusum* leaves were measured **using a Multiplex 3000 on leaves** of 10 individuals in the hay transfer and monospecific sowing treatments—(indicator of performance)

3. The cover of all vascular plant species was estimated in all treatments.

Fig. 3 : B. Retusum tagging to survival monitoring

Fig. 4 : leaves fluorescence measuremen with tMultiplex 3000

- Statistical analyses:
  - ANOVA was used to analyse univariate response variable
  - PCA to test effects on physiological traits of *B. retusum*
  - NMDS to examine plant community changes.

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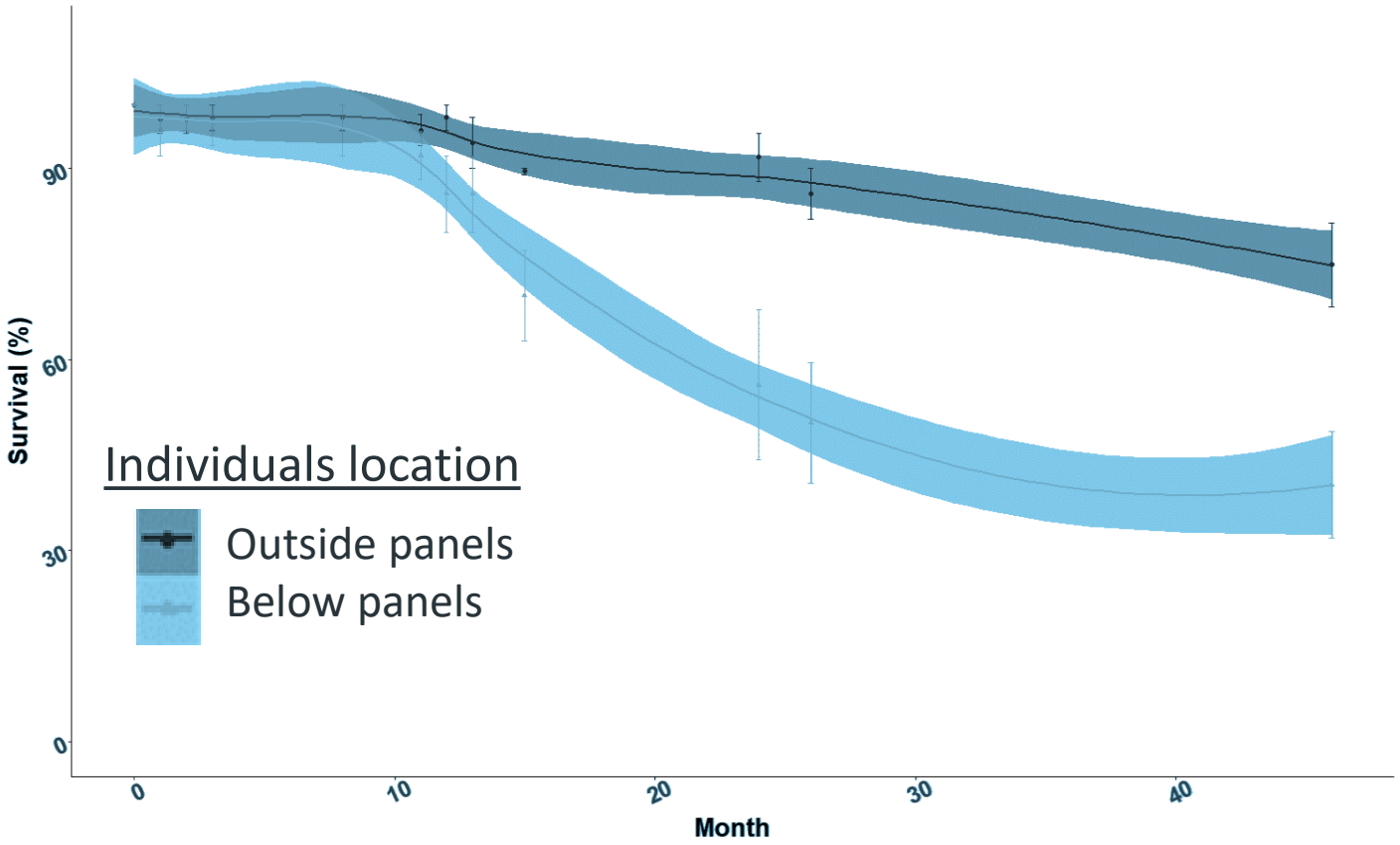

Fig.5 : Survival (in % of living individuals) of Brachypodium retusum evaluated under panels (SP, red) and outside panels (HP, blue), with 95 % confidence intervals

- In the **beginning no significant differences in *B. retusum* survival** were observed outside and under solar panels.
- **After 13 months, mortality increased under solar panels** resulting in highly significant differences to plants outside panels at the end of the study period.
- Thus, **young seedlings are less sensitive** to low light availability whereas light seems to become a limiting factor in adult plants.

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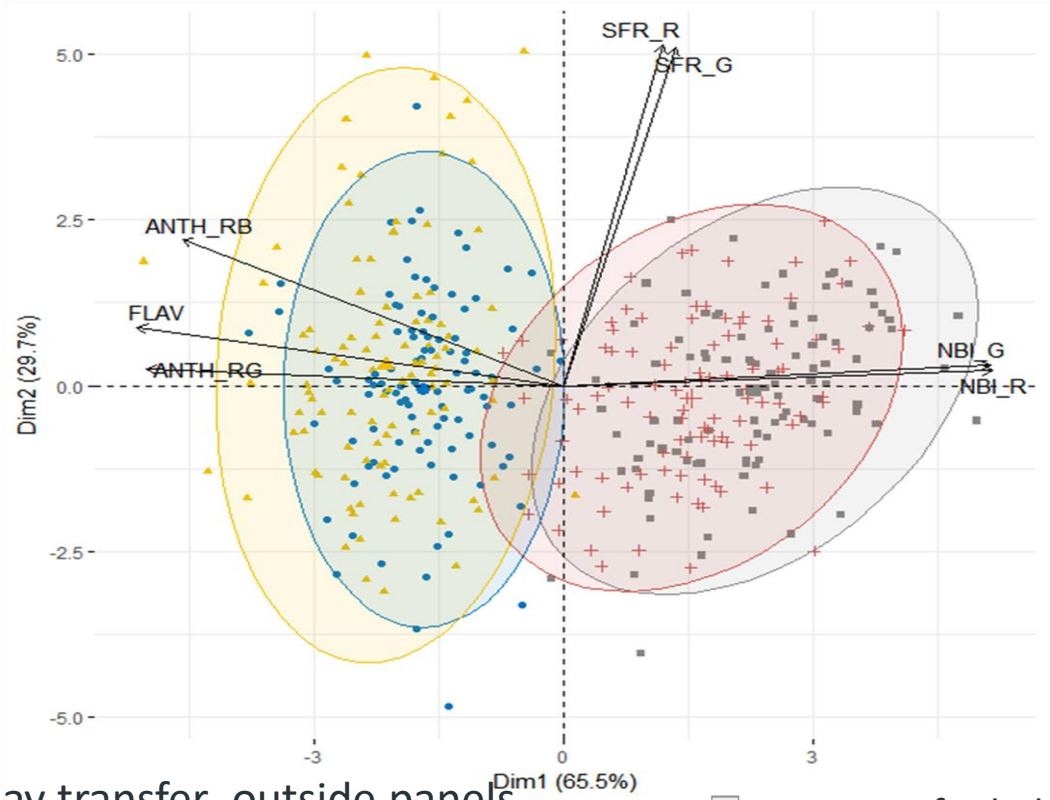

Hay transfer outside panels

Hay transfer below panels

Sowing outside panels

Sowing below panels

Fig.6 : : Principal Component Analysis (PCA) of ecophysyliogical estimates for plant performance and stress calculated from fluorescence signals of the B. retusum leaves. NBI : Nitrogen Balance Index, SFR : Chlorophyll Index . _R : Red excitation, _B: blue excitation, _G: green exitation

- **No differences between restoration techniques**
- The PCA (Fig. 3) showed that **Flavonoid and Anthocyanin** index were **higher** and nitrogen balance index was lower **outside solar panels**.
- **No effect** of solar panels **on chlorophyll index** (SFR) and.
- Lower light availability reduces flavonoid (FLAV) & anthocyanin (ANTH) content of leaves [3]

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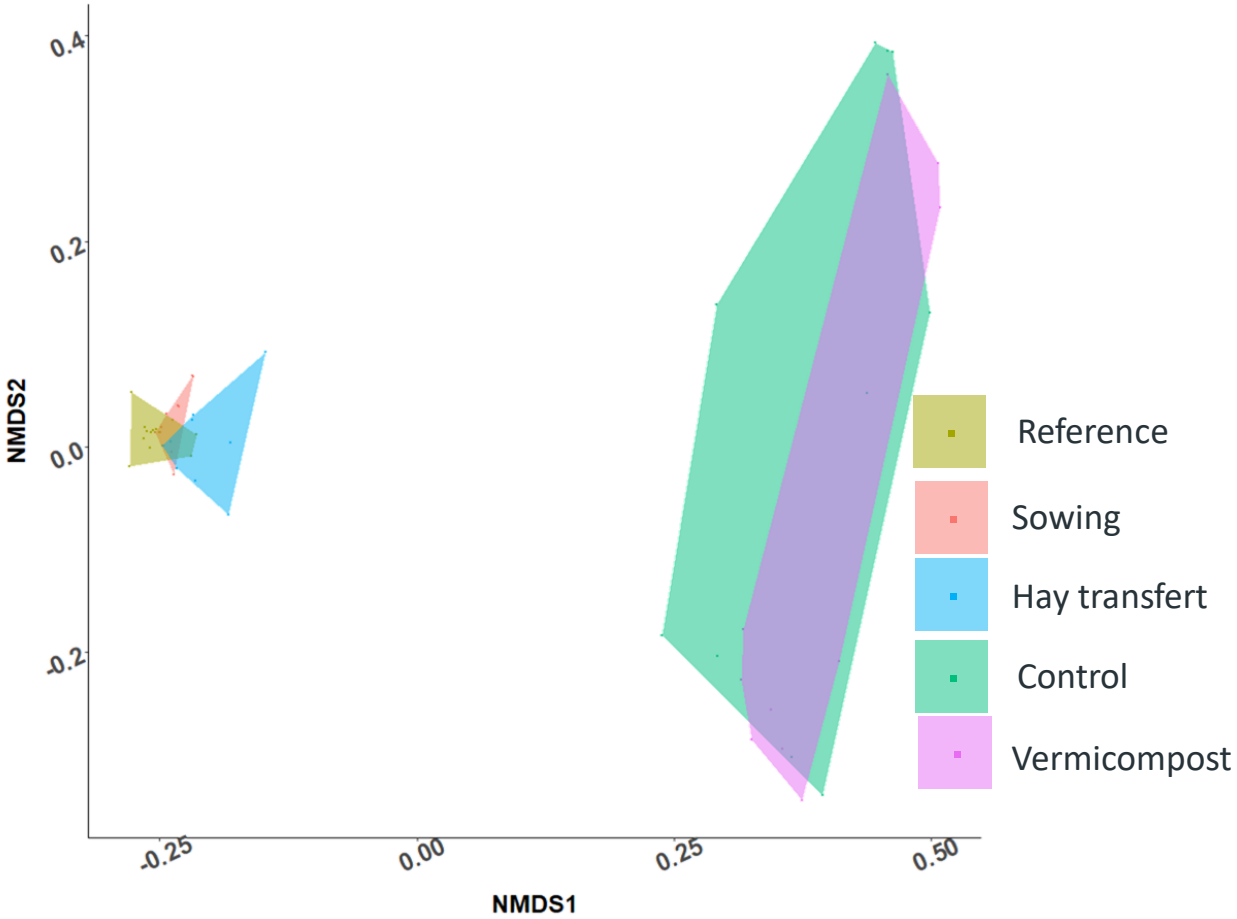

Fig. 7 : NMDS comparing the reference plant community with resroration methods in 2020 (stress = 0.02)

- After 4 years, **solar panels** did **not influence ecological restoration** towards the reference community (data not shown)
- The vermicompost and control treatment did not show community changes towards the reference ecosystem (Fig. 2).
- **The hay transfer and sowing treatment were most successful to establish the reference ecosystem *retusum* [2].**

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- **Solar panels increased mortality of the key species *B. retusum* and physiological** changes indicating light deficit stress suggest a future shift in community structure.

- **Hay transfer and monospecific *Brachypodium retusum sowing*** were both sucessful in accelerating succession towards the **the reference community**.

- Further observation is required to evaluate consequences of solar panels on soil restoration success.

Reference :[1] ARMSTRONG, A., OSTLE, N. J. et WHITAKER, J., 2016. Solar park microclimate and vegetation management effects on grassland carbon cycling. In : Environmental Research Letters. Vol. 11, n° 7, p. 74016.7 ; [2] COIFFAIT-GOMBAULT, C., BUISSON, E. et DUTOIT, T., 2011b. Hay Transfer Promotes Establishment of Mediterranean Steppe Vegetation on Soil Disturbed by Pipeline Construction. In : Restoration Ecology. 1 mars 2011. Vol. 19, n° 201, p. 214-222. ; [3] ROBSON, T. Matthew, KLEM, Karel, URBAN, Otmar et JANSEN, Marcel A. K., 2015. Re-interpreting plant morphological responses to UV-B radiation. In : Plant Cell and Environment. Vol. 38, n° 5, p. 856-866.