

CURRICULUM VITAE

Part A. PERSONAL INFORMATION

CV date 26/12/2024

First name	Ciro		
Family name	Cabal Ruano		
e-mail	ciro.cabal@gmail.com		
Open Researcher and Contributor ID (ORCID) (*)	0000-0002-7222-1991		

(*) Mandatory

A.1. Current position

Position	Postdoctoral Researcher (Juan de la Cierva)		
Initial date	January 1st, 2024		
Institution	Universidad Rey Juan Carlos (Madrid)		
Department/Center	Instituto de Investigación en Cambio Global (IICG-URJC)		
Country	Spain	Tel. number	620380422
Key words	Root ecology, Root foraging strategies, Plant-plant interactions, Game theory models		

A.2: Previous professional status

Period	Position/Institution/Country/Interruption cause
01/04/2022 – 31/07/2022	Postdoctoral Research Associate / Museo de Ciencias Naturales, Spanish National Research Council (MNCN-CSIC) / Spain
01/10/2021 – 31/03/2022	Postdoctoral Research Associate / High Meadows Environmental Institute (HMEI) – Princeton University / United States of America
01/09/2018 – 30/09/2021	PhD Candidate / Dpt. Ecology and Evolutionary Biology (EEB) – Princeton University / United States of America
01/09/2016 – 31/08/2018	PhD Student / Dpt. Ecology and Evolutionary Biology (EEB) – Princeton University / United States of America
01/10/2015 – 30/08/2016	Predoctoral researcher / Museo de Ciencias Naturales, Spanish National Research Council (MNCN-CSIC) / Spain
01/03/2011 – 30/11/2013	Predoctoral researcher / Universidad Complutense de Madrid (projects commissioned for TRAGSATEC and the Spanish Ministry of Agriculture) / Spain

A.3. Education

PhD, Licensed, Graduate	University/Country	Year
PhD	Princeton University / United States	20/11/2021
Master of Arts	Princeton University / United States	05/06/2018
Master of Sciences	Universidad Complutense de Madrid / Spain	19/06/2013
Licensed	Universidad Complutense de Madrid / Spain	16/03/2011

Part B. CV SUMMARY

B.1. Scientific contributions

My scientific career focuses on the study of root foraging strategies and belowground plant-plant interactions. My approach relies on the Root Tragedy of the Commons (RToC). I initiated and had led* this research line since I read the paper by *Gersani et al. 2001* as a PhD student (*the reviewers of this proposal may realize that this field is the candidate's distinctive and original research line in all the departments and labs they have worked since 2020). I was readily fascinated by the theory, but also surprised that most subsequent publications either questioned or denied a theory that, following my understanding of their mathematical models, had the potential to become a fundamental principle of root competition research.

The RToC predicts that plants will invest suboptimally in roots following an exploitative response to competition. As a result, they overproduce roots compared to the investment predicted by cooperation models. When it was first published, the RToC was seen as a theory with the potential to explain fine root production in competitive contexts, but it has become a contentious idea over the last two decades. Unfortunately, such an exciting theory has fallen into oblivion after becoming an object of unresolved theoretical dispute grounded in methodological controversy and intensified by a misunderstanding of the underlying mechanisms.

In my career, one of my main aims is to revive the interest in the RToC from a conciliatory and constructive approach, because I believe that this theory has the potential to advance significantly our understanding of plant foraging strategies and belowground plant-plant interactions.

Following this endeavor, my research usually lays in the interface between:

- Elaborating mathematical game-theory models of root competition and plant-plant belowground foraging strategies.
- Designing experiments to validate empirically my model results.
- Developing novel empirical methods to study the ecophysiology of roots of individual plants.

B.2. Contributions to society

- 1 THE NICHE, autumn 2024. News and Views: [Adapting roots in the context of Global Change](#). Vol 55 (3), p. 12.
- 2 NEW YORK TIMES, Cara Giaimo, 2020 [How Selfish Are Plants? Let's Do Some Root Analysis](#)
- 3 LA REPUBBLICA, Viola Rita, 2020 [La vita sociale delle piante: lottano per la sopravvivenza, ma si aiutano tra loro](#)
- 4 EL MUNDO, Paco Rego, 2020 [El viaje a las raíces de Ciro, el biólogo 'fugado' a la Universidad de Einstein](#)

B.3. Training and mentoring of young researchers

B.3.1 Teaching (Year/Code/University/Course name/Task/Hours)

2016/EEB211/Princeton University/Life on Earth: Mechanisms of Change in Nature/AI in labs/34h

2017/ENV200/Princeton University/The Environmental Nexus/AI Admin/34h

2018/EEB346/Princeton University/Biology of Coral Reefs/Field course in Panamá/34h

2023/2336025/URJC/Ecología de Grado de CC. Experimentales/Lecturing/18h

2023/2336025/URJC/Ecología de Grado de CC. Experimentales/Field/6h

2023/2338012/URJC/Producción de Mat. Primas del Grado de CyT Alimentos/Field TA/4h

2023/2336002/URJC/Biología de Grado de CC. Experimentales/Field TA/4h

2024/2317/URJC/Impacto de la Actividad Humana en la Biosfera G. en Biología/Lecturing/18h

2024/2317/URJC/Impacto de la Actividad Humana en la Biosfera G. en Biología/Field/8,5h

2024/2347/URJC/Fundamentos Biológicos del Grado de Matemáticas/Lecturing/17h

2024/2337/URJC/Ecología de Grado de CC. Ambientales/Field and Lab TA/21h

2024/2365/URJC/Diseño, Toma de Datos y Análisis de Experimentos del G. en Biología/Field TA/5h

B.3.2 Bachelor degree's final thesis (TFGs) directed (Year/University/Student/Title/Grade)

2018-19/UCM (co-advised by Fernando Valladares MNCN-CSIC)/Aurora de Castro Aguilar/Distribución de las raíces del pimiento (*Capsicum annuum* var. luesia) en presencia y ausencia de competidores conespecíficos: ¿hay tragedia de los comunes?/9,6/(10)

2024-25/URJC/Mario Chico Rodríguez/Diseño de macetas con raíces artificiales para evaluar la sobreproliferación de raíces como respuesta a las plantas al agotamiento de los recursos del suelo/ongoing

2024-25/URJC (co-advised by Saúl Ares García CNB-CSIC)/Juan Drago Tanuri/Efecto de los nutrientes en la resistencia de *E.coli* a los antibióticos/ongoing

2024-25/URJC/Carlos Tiemblo Herrero/Estrategias de conservación basadas en instrumentos de mercado voluntarios/ongoing

B.3.3 External internships directed (Year/University/Student/Host Center/Grade)

2018-19/UCM/Aurora de Castro Aguilar/MNCN-CSIC/9,9/(10)

2019-20/URJC/Laura Rodríguez Torres/MNCN-CSIC/9,8/(10)

B.4. Other contributions that you consider relevant

[John L Harper Award 2024](#), British Ecological Society, for my funded project **TRAgEDy** (C.3.3)

Judge for student prizes (best poster and oral presentation) at the BES annual meeting 2024 (11-13 December, Liverpool).

Reviewer for international journals such as Journal of Ecology, Functional Ecology, Oikos, New Phytologist, Communication Biology – Nature...

Part C. RELEVANT MERITS**C.1. Publications**

(author order/total number of coauthors); * indicates corresponding author

1 Research paper (1/3). **Ciro Cabal**; Gabriel A Maciel; Ricardo Martínez García*. 2024. Plant antagonistic facilitation across environmental gradients: a soil-resource ecosystem engineering model. *New Phytologist*. 244/2, pp.670-682. <https://doi.org/10.1111/nph.20053>

2 Research paper (1/3) **Ciro Cabal***; Fernando Valladares; Stephen W Pacala. 2024. Root Foraging Strategies and Niche Segregation of three Mediterranean Shrub Species. *Oikos*. <https://doi.org/10.1111/oik.10724>

3 Research paper (2/7) Ricardo Martínez García*; **Ciro Cabal**; Justin M Calabrese; Emilio Hernández García; Corina E Tarnita; Cristóbal López; Juan A. Bonachela. 2023. Integrating theory and experiments to link local mechanisms and ecosystem-level consequences of vegetation patterns in drylands. *Chaos, Solitons and Fractals*. <https://doi.org/10.1016/j.chaos.2022.112881>

4 Research paper (1/1) **Ciro Cabal*** 2022. Root tragedy of the commons: Revisiting the mechanisms of a misunderstood theory. *Frontiers in Plant Science*. <https://doi.org/10.3389/fpls.2022.960942>

5 Research paper (1/8) **Ciro Cabal***; Laura Rodríguez Torres; Neus Marí-Mena; Antonio Más Barreiro; Antón Vizcaíno; Joaquín Vierna; Fernando Valladares; Stephen W Pacala. 2022. Comparing two field protocols to measure individual shrubs' root density distribution. *Plant and Soil*. <https://doi.org/10.1007/s11104-022-05657-12>

6 Research paper (1/5) **Ciro Cabal***; Ricardo Martínez García; Aurora de Castro Aguilar; Fernando Valladares; Stephen W Pacala. 2021. Future paths for the "exploitative segregation of plant roots" model. *Plant Signaling and Behavior*. <https://doi.org/10.1080/15592324.2021.1891755>

7 Research paper (1/3) **Ciro Cabal***; Hannes PT De Deurwaerder; Silvia Matesanz. 2021. Field methods to study the spatial root density distribution of individual plants. *Plant and Soil*. <https://doi.org/10.1007/s11104-021-04841-z>

8 Research paper (1/5) **Ciro Cabal***; Ricardo Martínez García; Aurora de Castro Aguilar; Fernando Valladares; Stephen W Pacala. 2020. The Exploitative Segregation of Plant Roots. *Science*. <https://doi.org/10.1126/science.aba9877>

9 Research paper (1/2) **Ciro Cabal***; Daniel I Rubenstein. 2018. Above- and below-ground allocation and functional trait response to soil water inputs and drying rates of two common savanna grasses. *Journal of Arid Environments*. <https://doi.org/10.1016/j.jaridenv.2018.06.008>

- 10 Research paper (2/5)** Rut Sánchez de Dios; **Ciro Cabal**; Felipe Domínguez Lozano; Helios Sainz Ollero; Juan Carlos Moreno Saiz*. 2017. The role of criteria in selecting important areas for conservation in biodiversity-rich territories. *Diversity and Distributions*. <https://doi.org/10.1111/ddi.12535>
- 11 Research paper (1/4)** **Ciro Cabal**; Raúl Ochoa Hueso; María Esther Pérez Corona; Esteban Manrique*. 2017. Long-term simulated nitrogen deposition alters the plant cover dynamics of a Mediterranean rosemary shrubland in Central Spain through defoliation. *Environmental Science and Pollution Research*. <https://doi.org/10.1007/s11356-017-8879-7>
- 12 Book section (2/5)** Rut Sánchez de Dios, **Ciro Cabal** et al., 2014. Mapas de Sistemas Naturales de Vegetación del Parque Nacional de Monfragüe *IN*: Helios Sainz Ollero, Emilio Blanco Castro, Juan Antonio Durán Gómez, Rut Sánchez de Dios, 2014. Los Sistemas Naturales del Parque Nacional de Monfragüe, Memoria y Mapa de Vegetación. *Organismo Autónomo de Parques Nacionales, Madrid*. ISBN 9788480148665.
- 13 Research paper (1/3)** **Ciro Cabal***; Pilar Hurtado Aragües, Miguel García Toscano. 2013. Comparación de las Comunidades Vegetales de un Quejigar (*Cephalanthero longifoliae-Quercetum fagineae* Rivas-Martínez en Rivas Goday 1959) y un encinar (*Junipero thuriferae-Quercetum rotundifoliae* -Rivas Goday 1959- Rivas-Martínez 1982) Alcareños; Limitaciones de la Directiva de Hábitats en el Marco de la España Mediterránea. *Ecología (25) 121-136* ISSN 0214-0896

C.2. Congress

- 1 Oral presentation.** **Ciro Cabal**, Gabriel A. Maciel, and Ricardo Martinez-Garcia. 2024. Putting the Stress Gradient Hypothesis to the test: A soil-resource ecosystem engineering model to assess the ecological stability of plant antagonistic facilitation. *British Ecological Society Annual Meeting – Liverpool (United Kingdom)*, December 11-13th 2024
- 2 Oral presentation.** **Ciro Cabal** 2024 La tragedia de los comunes en raíces de plantas: una teoría incomprendida. Biodiverses Ecological Symposium 2024 Madrid (Spain) April 18th 2024
- 3 Invited presentation.** **Ciro Cabal**, Aurora de Castro Aguilar. 2021. De las aulas de Biológicas (UCM) a la portada de Science: La segregación por explotación de raíces de plantas. Ciclo La Biología en los Medios UCM. Madrid (Spain) December 17th 2021
- 4 Poster.** **Ciro Cabal**; Raúl Ochoa Hueso; María Esther Pérez Corona; Esteban Manrique The effect of nitrogen deposition on rosemary shrub dynamics. *II CAPERMED (Comittee on Air Pollution Effects Research on Mediterranean Ecosystems) meeting*. Brescia (Italy), June 28-30th 2016
- 5 Poster.** **Ciro Cabal**; Rut Sánchez de Dios; Felipe Domínguez Lozano; Helios Sainz Ollero; Juan Carlos Moreno Saiz. 2013. GAP analysis de las áreas importantes para la flora vascular española. *6º Congreso de la Biología de Conservación de Plantas (SEBICoP)*. Murcia (Spain), October 15-18th 2013

C.3. Research projects

- 1 Project PI:** **Ciro Cabal**, Convocatoria adquisición, ampliación y reparación de equipamiento científico 2024, **2024/SOLCON-60246**. Universidad Rey Juan Carlos. **29.987,32 €**, Awarded on the **10/12/2024**
- 2 Project PI:** **Ciro Cabal**, TIETAR: Las barreras de suelo como herramienta para aumentar la eficiencia en el uso de recursos agrícolas en el contexto de Cambio Global. **1ª Convocatoria proyectos de Investigación investigadores postdoctorales IICG-URJC 2024**, Instituto de Investigación en Cambio Global, Universidad Rey Juan Carlos (IICG-URJC). **2.900 €**, Awarded on the **29/11/2024**
- 3 Project PI:** **Ciro Cabal**, TRAgEDy: The Tragedy of the commons in Roots as an Agonistic Exploitative Dynamic in plants. Using artificially rooted pots to assess root overproliferation as a response to soil resource depletion. **BES Small Research Grant SR24\1219**, British Ecological Society. **£4,789.50**, Awarded on the **23/05/2024**
- 4 Project PI:** **Ciro Cabal**, Financiación adicional **Juan de la Cierva 2022**, **JDC2022-048613-I**, Agencia Estatal de Investigación, MCIU. **7.400 €**, Awarded on the **29/11/2023**

C.4. Contracts

- 1 Contract.** **Juan de la Cierva 2022**, Agencia Estatal de Investigación, MCIU. (**60.000€**, **JDC2022-048613-I**–24 months: 01/01/2024-01/01/2026, income).
- 2 Contract.** **The Robert May Fellowship in Ecology and Evolutionary Biology**, Princeton University. (**\$407.200**, **Princeton Award**–60 months: 01/09/2016-30/08/2021, tuition, fees and living expenses).