PROVIDE
PROVIding smart DElivery of public goods by EU agriculture and forestry

PROYECTO PROVIDE
Cuarta reunión con los agentes de la región de estudio ‘Andalucía’
(olivar de montaña en Andalucía)

Facultad de Derecho y Ciencias EE. y EE. (Univ. de Córdoba)
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UNIVERSIDAD DE CÓRDOBA

WEARE
Water, Environmental and Agricultural Resources Economics
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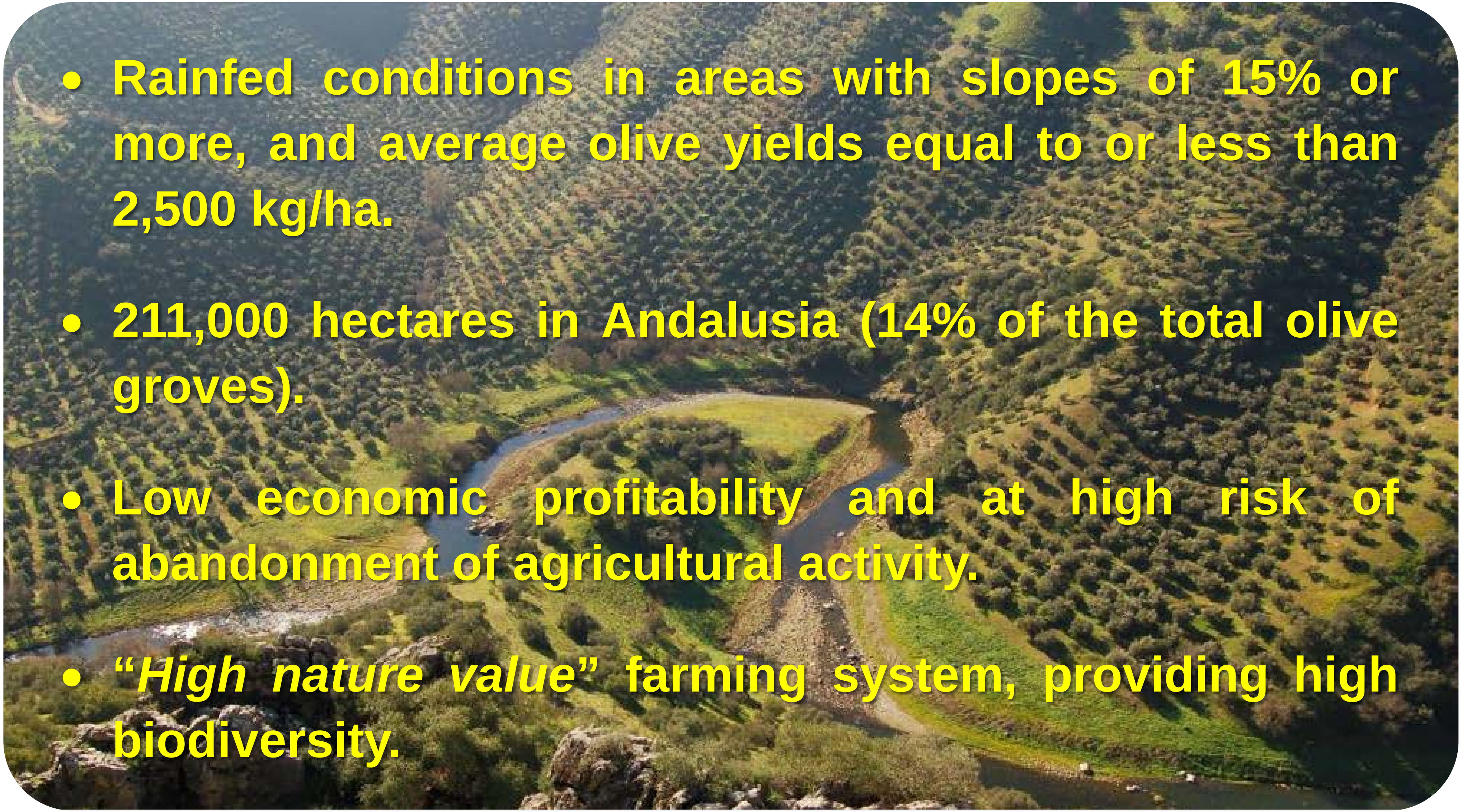
1. Introduction and objectives

- **New societal demands** aiming at a **smart provision of PGs** by the agricultural sector has become one of the main **policy objectives**.
- A number of **instruments** have been implemented, such as **agro-environmental schemes (AES)** included in the second pillar of the CAP.
- The effective design of AES is **challenging for policy-makers**, given the major **information gaps regarding the costs and benefits** of these instruments.
- AES have displayed problems of **information asymmetry**: ***adverse selection*** and ***moral hazard***, reducing the efficiency of these measures. Both problems have been extensively analyzed in the literature through **principal-agent models**.
- This paper takes an applied approach to provide **practical, realistic support** for the design and implementation of a new AES aimed at **improving biodiversity in Andalusian mountain olive groves (MOG)**.

2. AES for promoting biodiversity in MOG

Andalusian mountain olive groves



- Rainfed conditions in areas with slopes of 15% or more, and average olive yields equal to or less than 2,500 kg/ha.
- 211,000 hectares in Andalusia (14% of the total olive groves).
- Low economic profitability and at high risk of abandonment of agricultural activity.
- “*High nature value*” farming system, providing high biodiversity.

2. AES for promoting biodiversity in MOG

Proposal for a new AES aimed at improving biodiversity

- Numerous studies have identified **soil management practices** and **phytosanitary treatments** as the most important elements from an agri-environmental perspective.
- A possible AES might consist of **five-year contracts** through which olive growers would commit to employing, in exchange for an **annual per-hectare payment**, a set of **practices to improve the provision of biodiversity**.
- Agri-environmental **commitments** include certain levels of stringency for **cover crop area (CCA)**, **cover crop management (CCM)** and **insecticide treatment (INT)**.
- **Five alternative designs or scenarios** for AES application have been proposed.

2. AES for promoting biodiversity in MOG

Proposal for a new AES aimed at improving biodiversity

AES scenario	Level of stringency	Bird species/farm (no.)	Increase in bird species/farm (no.)
Integrated production	**CCA**: 30% of the MOG area under cover crops **CCM**: restricts the use of herbicides (they can be used in two of the five years) and tillage (only shallow tillage is allowed) **TIN**: limited treatment (dimethoate and copper oxychloride are not allowed)	13.0	5.2
Integrated production plus	**CCA**: 50% of the MOG area under cover crops **CCM**: management using only mower or animal grazing **TIN**: limited treatment (dimethoate and copper oxychloride are not allowed)	17.6	9.8
Ecological production	**CCA**: 50% of the MOG area under cover crops **CCM**: management using only mower or animal grazing **TIN**: only treatments used in organic production	19.8	12.0
Ecological production plus	**CCA**: 100% of the MOG area under cover crops **CCM**: management using only mower or animal grazing **TIN**: only treatments used in organic production	23.6	15.8
Provision of environmental public goods	**CCA**: 100% of the MOG area under cover crops **CCM**: non-management, except mowing or grazing the cover crops early in the summer to reduce fire risk **TIN**: non-treatment (use of any biocidal product is prohibited)	30.0	22.2

3. Principal-agent modelling

Farmer decision-making model

- Farmers’ decision-making is assumed to be take in **two successive stages**:
    1. First, the farmer decides **whether or not to take part in the scheme**:

$$p - \psi_i(E) \geq 0$$

p = payment quantified in €/hectare/year
$\psi_i(E)$ = cost of implementation in €/hectare/year

    2. If farmer decides to sign the corresponding contract, he is placed in a situation of ***moral hazard***, where he has to **decide on the degree of compliance** with the requirements to which he has committed: c_i, expresses contractual compliance, ranging from 0 to 1.

- It can be assumed that the farmer **tries to maximise the profit** associated with the AES:

$$\max_{c_i} \pi_i = \Big[\big[1 - \big(m\,\theta(c_i)\big)\big]\big[p - \psi_i(c_i E)\big]\Big] + \Big[\big[m\,\theta(c_i)\big]\big[p\big(1 - \rho(c_i)\big) - \psi_i(c_i E)\big]\Big]$$

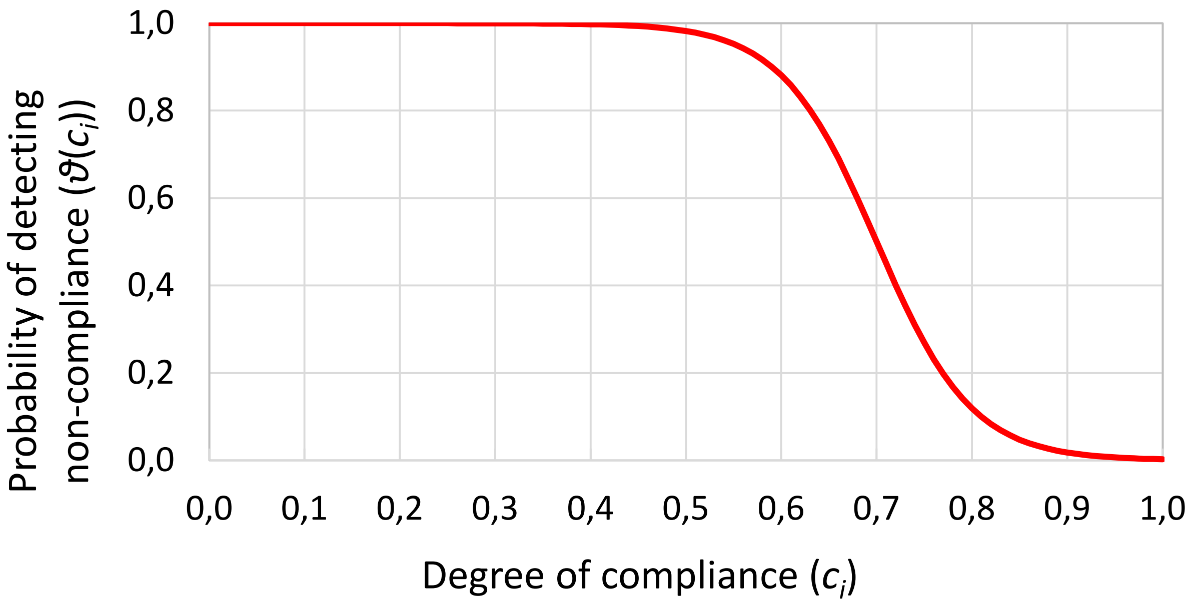
m = variable [0,1] measuring the % level of monitoring of the scheme.
$\theta(c_i)$ = function of the probability of detecting non-compliance with the scheme
$\rho(c_i)$ = variable [0,1] quantifying sanction for non-compliance as a percentage of the payment

3. Principal-agent modelling

Farmer decision-making model

- According to technicians consulted probabilities of $\boldsymbol{\theta(c_i)}$ can be adjusted as the following **Boltzmann sigmoid function**:

$$\theta(c_i) = 1 - \frac{1}{1 + e^{\frac{0.7 - c_i}{0.05}}}$$



- Operating and rearranging **profit expression**:

$$\max_{c_i} \pi_i = p - \psi_i(c_i E) - p\, m\, \theta(c_i)\, \rho(c_i)$$

- The **first-order condition** optimising the problem is:

$$\frac{\partial \pi_i}{\partial c_i} = -\frac{\partial \psi_i(c_i E)}{\partial c_i} E - p\, m \left[\frac{\partial \theta(c_i)}{\partial c_i} \rho(c_i) + \theta(c_i) \frac{\partial \rho(c_i)}{\partial c_i}\right] = 0$$

3. Principal-agent modelling

Public administration decision-making model

- The **decision variables** that the administration can consider as design parameters are E, p, m and $\rho(c_i)$.
- This study considers a **different AES application for each class of farmers** (i), with differences in the variables E_i, p_i and m_i for each class.
- **Principal's** decision problem centres on **maximising the social welfare**:

$$\max_{\gamma_i, E_i, p_i, m_i} Z = \sum_i \gamma_i w_i \begin{bmatrix} v(c_i E_i) + \big(p_i - \psi_i(c_i E_i)\big) - p_i\, MCF \\ + p_i\, m_i\, \theta(c_i)\, \rho(c_i)\, (MCF - 1) - M(m_i)\, MCF \end{bmatrix}$$

$$\text{s.a.} \quad p_i - \gamma_i \psi_i(E_i) \geq 0 \qquad \forall i$$

$$\gamma_i \left[\frac{\partial \psi_i(c_i E_i)}{\partial c_i} E_i + p_i\, m_i \left(\frac{\partial \theta(c_i)}{\partial c_i} \rho(c_i) + \theta(c_i) \frac{\partial \rho(c_i)}{\partial c_i} \right) \right] = 0 \qquad \forall i$$

$v(c_i E_i)$ = the benefit to society resulting from the improvement in the provision of the biodiversity
MCF = marginal cost of public funds (shadow price for each € invested in any public spending policy)
$M(m_i)$ = cost of monitoring the scheme
γ_i = a binary variable that; γ_i=1 when farm type *i* participates, and the value γ_i=0 when does not

4. Results

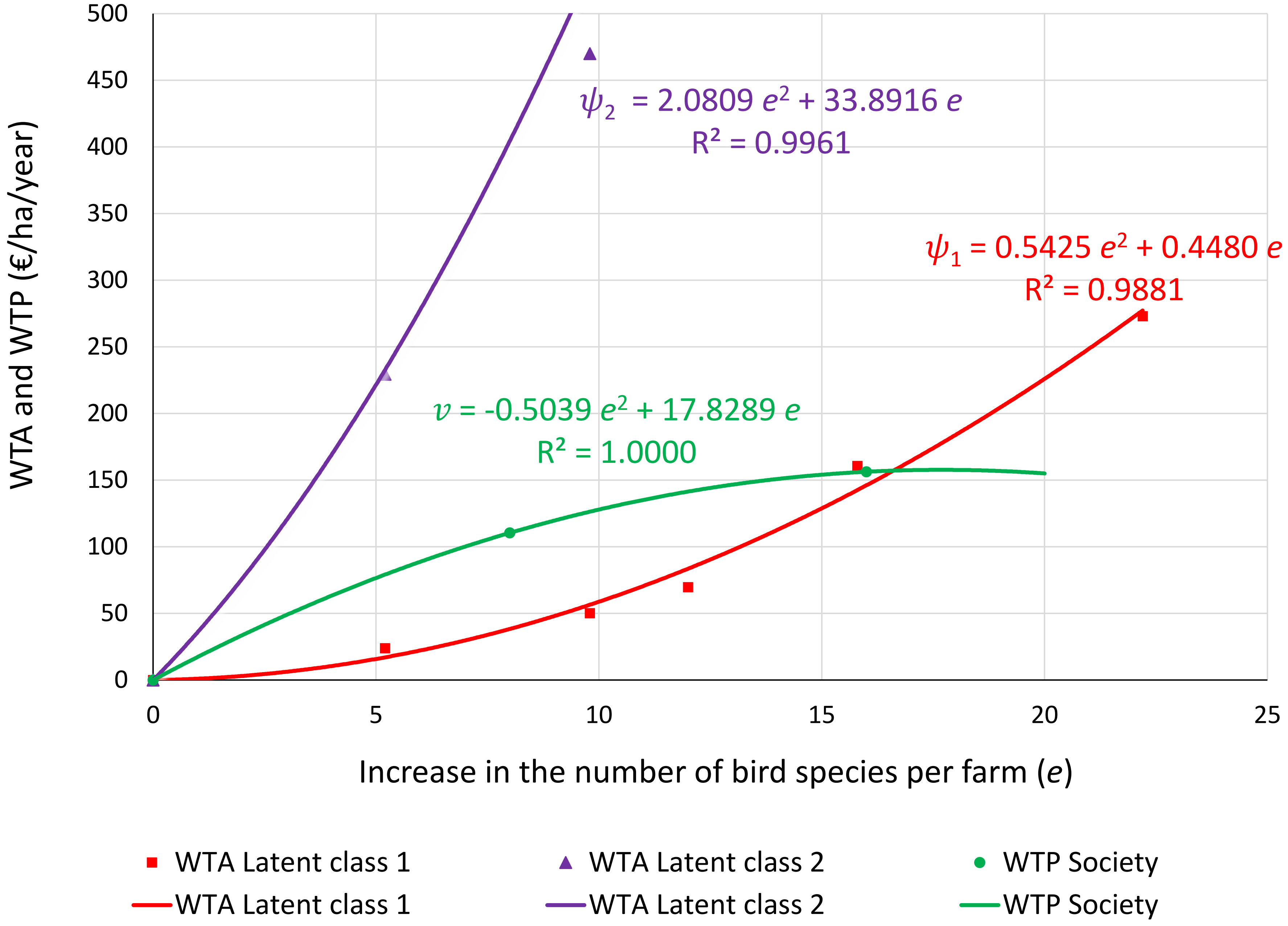
Cost of provision of biodiversity between MOG farmers

- Valuation exercise carried out as part of the **PROVIDE project** determined the **WTA for improvements in the biodiversity** by means of **choice experiments** exercise using a **latent class model (LCM)**.
- This model reveals the existence of **two classes of mountain olive farmers**, clearly differentiated according to their costs of provision.

The social benefit from the improvement in biodiversity

- Valuation exercise also carried out as part of the **PROVIDE project** determined the **WTP for improvements in the biodiversity** by means of **choice experiments** exercise using a **random parameter logit model (RPL)**.

4. Results


WTA and WTP (€/ha/year)
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
Increase in the number of bird species per farm (e)
ψ_2 = 2.0809 e^2 + 33.8916 e
R^2 = 0.9961
ψ_1 = 0.5425 e^2 + 0.4480 e
R^2 = 0.9881
υ = -0.5039 e^2 + 17.8289 e
R^2 = 1.0000
■ WTA Latent class 1
▲ WTA Latent class 2
● WTP Society
WTA Latent class 1
WTA Latent class 2
WTP Society

4. Results

Optimal AES design

- The high WTA in **Class 2** means that this group's costs to increase biodiversity provision ($\psi_2(e)$) exceed the associated social benefit ($v(e)$) for any level of improvement in this public good (e). Hence, this class **does not participate in this scheme** (γ_2=0).

- This first result **simplifies the management** and **reduces the problems of adverse selection** (a single agri-environmental contract designed for farms with the lowest costs of provision -Class 1-).

- The optimal values for the principal's decision variables (*E*, *p* and *m*) and the objective function (*Z*) **depend on the value assigned to the MCF parameter**.

4. Results

Optimal AES design

	Base scenario	$\psi_i(e_i)$		$v(e)$	
		+10%	-10%	+10%	-10%
Z (€/ha)	9.75	8.08 (-17.1%)	11.72 (20.3%)	13.95 (43.1%)	6.09 (-37.5%)
p (€/ha)	97.30	92.22 (-5.2%)	102.38 (5.2%)	111.35 (14.4%)	81.77 (-16.0%)
E (no. species)	6.2	5.6 (-10.1%)	7.0 (11.4%)	7.2 (15.2%)	5.2 (-16.7%)
m (%)	15.0	14.2 (-5.2%)	18.8 (5.2%)	17.2 (14.4%)	12.6 (-16.0%)
c_1 (%)	67.7	67.7 (0.0%)	67.7 (0.0%)	67.7 (0.0%)	67.7 (0.1%)
e_1 (no. species)	4.2	3.80 (-10.1%)	4.70 (11.4%)	4.86 (15.1%)	3.52 (-16.7%)
$\psi_1(e_1)$ (€/ha)	11.56	10.47 (-9.4%)	12.69 (9.9%)	14.98 (29.6%)	8.28 (-28.3%)
π_1 (€/ha)	82.84	79.15 (-4.5%)	86.47 (4.4%)	92.55 (11.7%)	71.45 (-13.8%)
$v(e_1)$ (€/ha)	66.28	60.41 (-8.9%)	72.70 (9.7%)	82.20 (24.0%)	50.81 (-23.3%)

4. Results

Optimal AES design

	Base scenario	MCF		k	
		+10%	-10%	+10%	-10%
Z (€/ha)	9.75	3.49 (-64.1%)	20.43 (109.7%)	8.64 (-11.3%)	10.96 (12.5%)
p (€/ha)	97.30	55.66 (-42.8%)	199.73 (105.3%)	97.15 (-0.2%)	96.97 (-0.3%)
E (no. species)	6.2	4.2 (-32.5%)	8.6 (38.5%)	5.9 (-5.1%)	6.6 (5.3%)
m (%)	15.0	12.5 (-16.8%)	13.7 (-8.8%)	13.6 (-9.2%)	16.6 (10.7%)
c_1 (%)	67.7	67.7 (0.1%)	67.7 (0.0%)	67.7 (0.0%)	67.7 (0.0%)
e_1 (no. species)	4.2	2.85 (-32.4%)	5.85 (38.6%)	4.01 (-5.0%)	4.44 (5.3%)
$\psi_1(e_1)$ (€/ha)	11.56	5.69 (-50.8%)	21.18 (83.3%)	10.51 (-9.0%)	12.70 (9.9%)
π_1 (€/ha)	82.84	48.60 (-41.3%)	173.12 (109.0%)	84.01 (1.4%)	81.06 (-2.2%)
$v(e_1)$ (€/ha)	66.28	46.75 (-29.5%)	87.04 (31.3%)	63.37 (-4.4%)	69.28 (4.5%)

4. Results

AES design for future scenarios

$$\max_{\gamma_i,E_i,p_i,m_i} Z = \sum_i \gamma_i w_i \left[\begin{array}{c} v(c_iE_i) + \left(p_i - \psi_i(c_iE_i)\right) - p_i\, MCF \\ + p_i\, m_i\, \theta(c_i)\, \rho(c_i)\, (MCF - 1) - M(m_i)\, MCF \end{array} \right]$$

$$\text{s.t.} \quad p_i - \gamma_i \psi_i(E_i) \geq 0 \qquad \forall i$$

$$\gamma_i \left[\frac{\partial \psi_i(c_iE_i)}{\partial c_i} E_i + p_i\, m_i \left(\frac{\partial \theta(c_i)}{\partial c_i} \rho(c_i) + \theta(c_i) \frac{\partial \rho(c_i)}{\partial c_i} \right) \right] = 0 \qquad \forall i$$

Business as usual scenario

(variations from current values):

- Compliance costs $\psi_i(E)$: **-10%.**
- Social benefits $v(c_iE_i)$: **+10%.**
- Monitoring cost $M(m_i)$: **-20%.**
- Sanctions for non-compliance $\rho(c_i)$: **+20%.**

Sustainability driven scenario

(variations from current values):

- Compliance costs $\psi_i(E)$: **+10%.**
- Social benefits $v(c_iE_i)$: **+30%.**
- Monitoring cost $M(m_i)$: **-40%.**
- Sanctions for non-compliance $\rho(c_i)$: **+100%.**

Market driven scenario

(variations from current values):

- Compliance costs $\psi_i(E)$: **+20%.**
- Social benefits $v(c_iE_i)$: **+0%.**
- Monitoring cost $M(m_i)$: **-20%.**
- Sanctions for non-compliance $\rho(c_i)$: **+0%.**

4. Results

AES design for future scenarios

	Base scenario	Business as usual	Sustainability driven	Market driven
$\boldsymbol{Z}$ (€/ha)	9.75	21.70 (+122.7%)	37.39 (+283.6%)	8.99 (-7.8%)
$\boldsymbol{p}$ (€/ha)	97.30	107.54 (+10.5%)	94.32 (-3.1%)	87.86 (-9.7%)
$\boldsymbol{E}$ (no. species)	6.2	9.0 (+45.0%)	10.8 (+73.0%)	5.7 (-8.2%)
$\boldsymbol{m}$ (%)	15.0	20.7 (+5.7%)	24.3 (+9.2%)	16.9 (+1.9%)
$\boldsymbol{c_1}$ (%)	67.7	67.5 (-0.2%)	67.1 (-0.4%)	67.6 (+0.5%)
$\boldsymbol{e_1}$ (no. species)	4.2	6.1 (+44.6%)	7.2 (+71.6%)	3.9 (-8.2%)
$\boldsymbol{\psi_1(e_1)}$ (€/ha)	11.56	20.66 (+78.8%)	34.88 (+201.8%)	11.85 (+2.6%)
$\boldsymbol{\pi_1}$ (€/ha)	82.84	82.38 (-0.6%)	54.62 (-34.1%)	73.04 (-11.8%)
$\boldsymbol{v(e_1)}$ (€/ha)	66.28	99.07 (+49.5%)	133.51 (+101.5%)	61.51 (-7.2%)

5. Conclusions

- This study demonstrates the **utility of PAM in supporting the design of AES**, minimising the problems of adverse selection and moral hazard.

- The **information required** to build these types of models in the real world is not available through official statistics. The **time and high costs** involved in generating this information would **only be feasible for the design of large-scale AES**.

- **Second-best solutions yielded by the PAM differ significantly from the optimal achievable in the ideal case of perfect information**. The optimal solutions from the models reveal that **only a small part of the AES payments goes towards compensating farmers for the extra costs** incurred; most of this payment is converted to income.

- In order to improve the performance of these schemes, it is suggested to **modify the current sanction system**.

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6. SWOT analysis

	Factor	Importance (tick the three most important factors in each category)
Strengths		
Weaknesses		
Opportunities/ enabling factors		
Threats/barriers		

7. Evaluation of the SWOT

	Criteria	Average importance of criteria, w_i (scores obtained through direct point allocation)	Average scoring of policy instrument against the criteria, s_i (values between 0 and 10)
Strengths	**S1**		
	S2		
	S3		
Weaknesses	**W1**		
	W2		
	W3		
Opportunities / enabling factors	**O1**		
	O2		
	O3		
Threats / Barriers	**T1**		
	T2		
	T3		
Desirable characteristics / indicators	**I1** Targeted to the topic		
	I2 Low Ancillary costs		
	I3 Ancillary benefits		
	I4 Measurability		
	I5 Effectiveness		
	I6 Acceptance		

Thank you very much for your attention!!!

Comments and suggestions?

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