Is punishment always effective? Evidence from an experimental study

Demographics

More statistics on the data from the qualification test are shown below.

Table 1. Age vs. Qualification

	Qualified		Total
	No	Yes	
Age			
Under 18	2	0	2
18 - 24	180	72	252
25 - 34	1,081	462	1,543
35 - 44	710	324	1,034
45 - 54	297	174	471
55 - 64	178	76	254
65 - 74	48	32	80
75 - 84	2	2	4
85 or Older	3	1	4
Gender			
Female	1,040	590	1,630
Male	1,461	553	2,014
Education			
4-year Degree	1,434	596	2,030
Doctorate	29	21	50
High School Graduate	162	95	257
Less than High School	5	3	8
Professional Degree	508	200	708
Some College	363	228	591
Experience			
None	336	547	883
Less than 1 Year	323	142	465
1-3 Years	994	243	1,237
3-6 Years	573	115	668
More than 6 years	275	96	371
Employment			
Homemaker	119	71	190
Retired	64	40	104
Student	45	33	78
Unemployed	65	49	114
Working full-time	1,827	778	2,605
Working part-time	381	172	553
Income			
Under $10,000	208	144	352
$10,000-$20,000	275	128	403
$20,000-$30,000	392	156	548
$30,000-$45,000	430	201	631
$45,000-$60,000	569	221	790
$60,000-$80,000	370	151	521
$80,000-$120,000	209	90	299
Over $120,000	48	52	100

Groundwater recharge

Researchers have shown that overextraction and exhaustion of groundwater can affect the recharge rate (Tsur & Zemel, 2004). In other words, complete groundwater depletion can lead to irreversible aquifer deformation and destruction, preventing storage of water. Figure 1 shows different patterns of behavior with respect to the key selected variables (scenarios S1 to S6). S1 is the baseline where orchards and pumping rate do not change, and the groundwater level remains constant.

S2, S3, and S4 show that orchards area increases and then decreases over time. S2 shows a slight increase in orchards, resulting in decline of groundwater. As orchards reaches the initial value, groundwater stops declining and stays at a new equilibrium. The pumping rate falls below the desired level because of the effect of lower groundwater level on outflow. S3 exhibits a higher increase in orchards in the early periods. As a result, groundwater level decreases, leading to a lower pumping rate. However, as orchards area declines and remains low for several periods, groundwater gradually grows, reaching to its initial value. S4 shows that a much higher increase in orchards leads to a huge decline in groundwater, resulting in extremely lower water inflow. Because the aquifer is exceedingly depleted, the inflow remains low even after orchards area declines.

S5 and S6 show that orchards area declines and then increases over time. S5 demonstrates a huge decrease in orchards area resulting in a constant increase in groundwater level. Groundwater growth becomes slower as orchards area returns to the equilibrium. S6 shows that although groundwater increases for several periods due to a decrease in orchards, it declines as orchards grow and remain above the equilibrium.

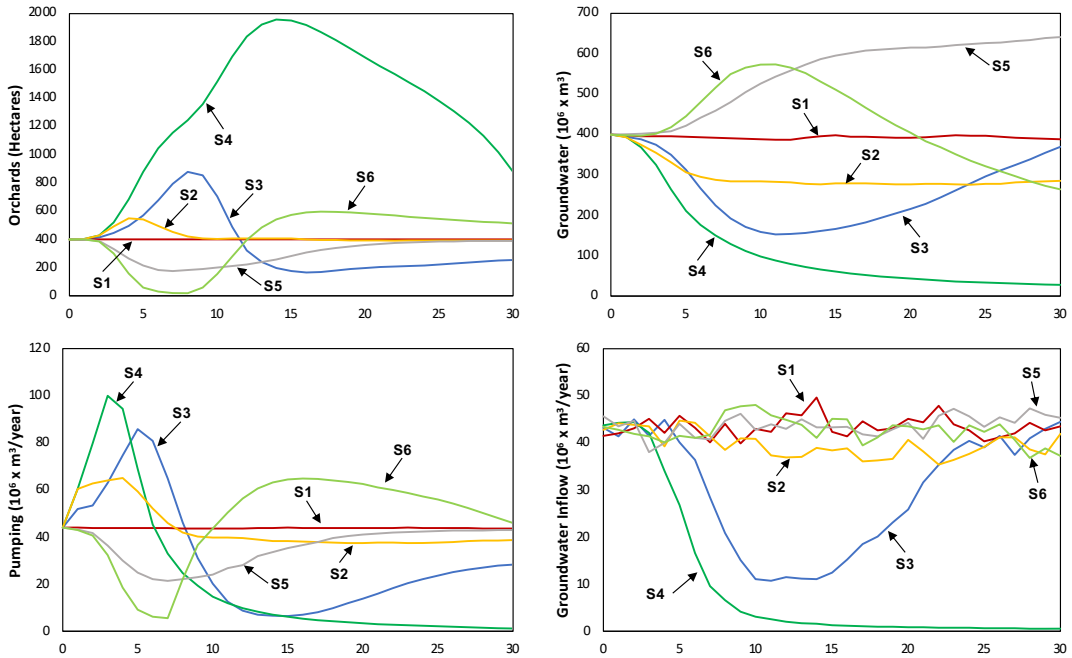

Figure 1. Different patterns of behavior regarding the key selected variables; orchards, groundwater, pumping rate, and groundwater inflow.

Groundwater co-flow

We used a co-flow structure to capture the individual effect of pumping rates on groundwater as well as their separate impacts on production.

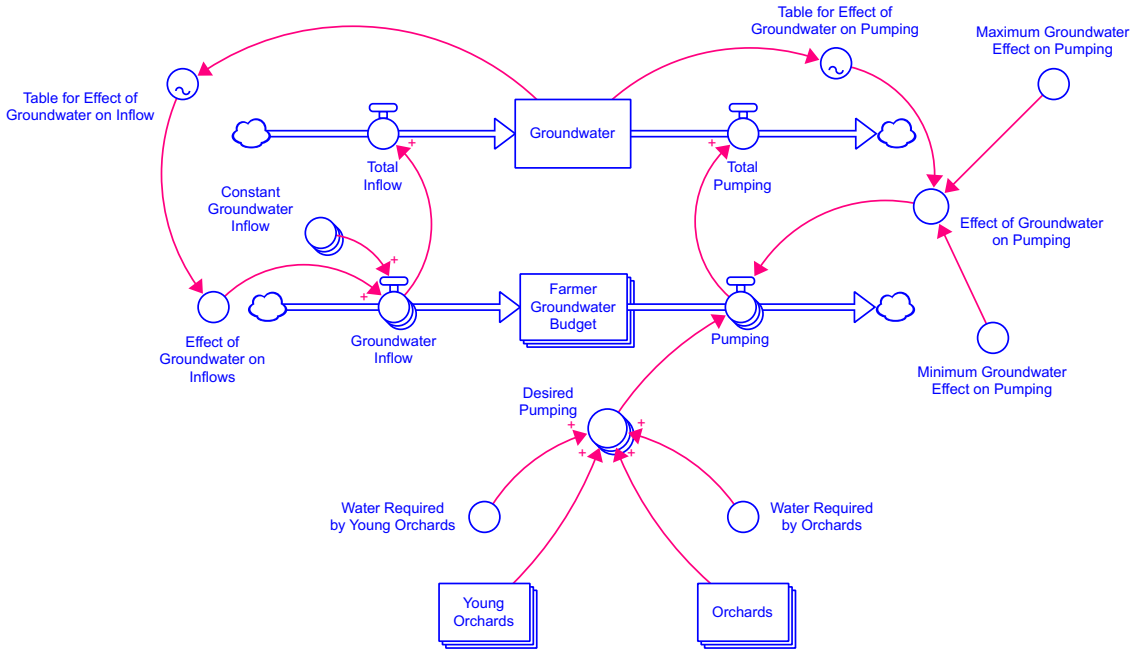

Figure 2. Implementation of the co-flow structure in the groundwater sector

Additional information on orchards sector

We explicitly captured the third-order delay for young orchards using three separate stocks (Figure 3). We used first-order delays governing the outflows (Y_{12}, Y_{23}, and GR_O) to calculate the changes in young orchards (Y_1, Y_2, and Y_3):

$$Y_1 = GR_Y - Y_{12} \tag{1}$$

$$Y_2 = Y_{12} - Y_{23} \tag{2}$$

$$Y_3 = Y_{23} - GR_O \tag{3}$$

We captured the outflows as the stocks divided by the third of the growth delay time (τ^*_{GD}):

$$Y_{12} = Y_1 / \tau^*_{GD} \tag{4}$$

$$Y_{23} = Y_2 / \tau^*_{GD} \tag{5}$$

$$GR_O = Y_3 / \tau^*_{GD} \tag{6}$$

$$\tau_{GD} = \tau^*_{GD} / 3 \tag{7}$$

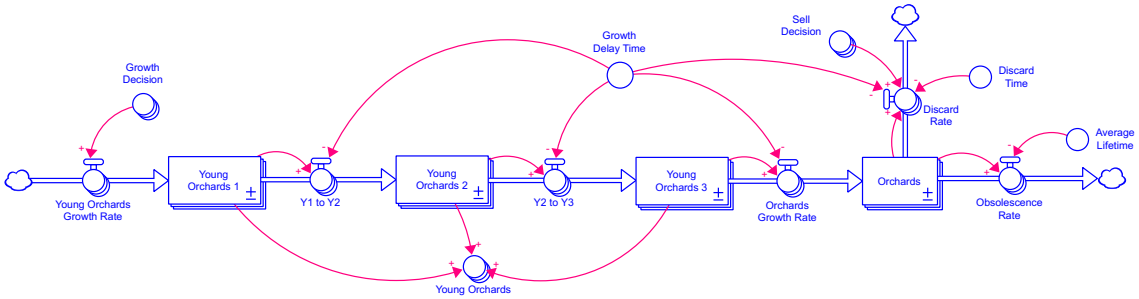

Figure 3. Implementation of the third-order delay on the orchard sector

Recruiting process

In this section, we provide more details on the recruiting process on Amazon Mechanical Turk (MTurk). The first stage is to publish a Human Intelligence Task (HIT) containing a demographics survey, experiment instructions, and a qualification test. Figure 4 shows the first page a user sees when joining the survey link.

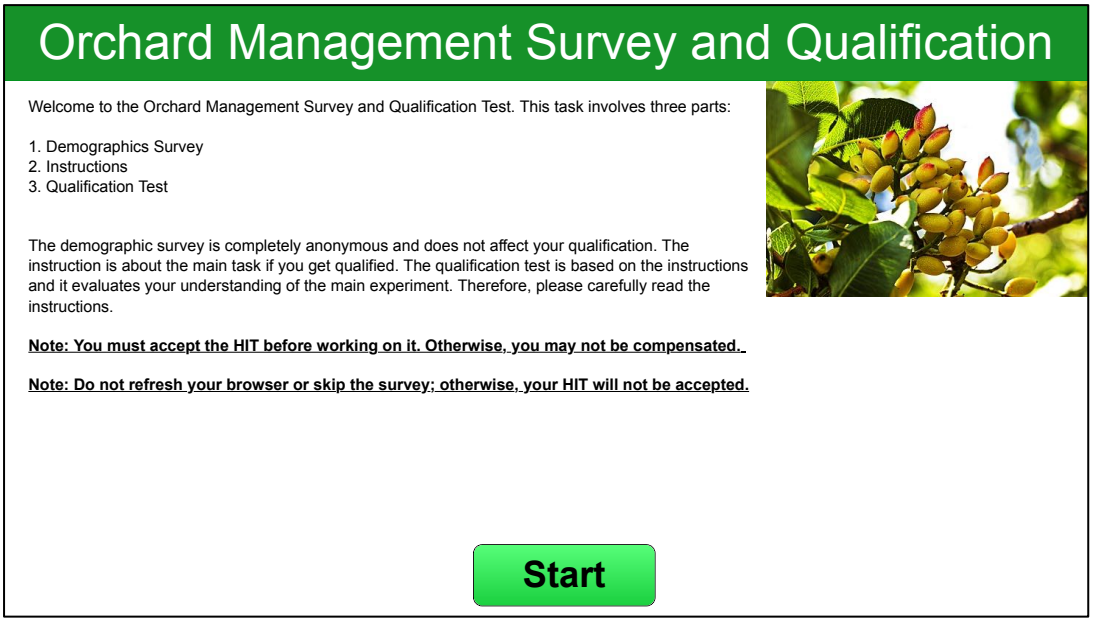

Figure 4. The first a page a user sees when joining the survey link.

Demographics

The survey comes before the qualification test and the experiment. We used the following questions to gather data about the users potentially attending the experiments:

This survey is anonymous and your answer to these questions do **NOT** impact your qualification.

1. What is your age group?
    a. Under 18
    b. 18 – 24
    c. 25 – 34
    d. 35 – 44
    e. 45 – 54
    f. 55 – 64
    g. 65 – 74
    h. 75 – 84
    i. 85 or older
2. What is your gender?
    a. Male

    b. Female
3. What is your highest level of education?
    a. Less than high school
    b. High school graduate
    c. Some college
    d. 4-year degree
    e. Professional degree
    f. Doctorate
4. How much experience do you have working in the agriculture sector (e.g., manager, engineer)?
    a. None
    b. Less than 1 year
    c. 1-3 Years
    d. 3-6 Years
    e. More than 6 years
5. What is your current employment status?
    a. Student
    b. Homemaker
    c. Retired
    d. Unemployed
    e. Working Part-time
    f. Working Full-time
6. How much is your annual gross income?
    a. Under $10,000
    b. $10,000-$20,000
    c. $20,000-$30,000
    d. $30,000-$45,000
    e. $45,000-$60,000
    f. $60,000-$80,000
    g. $80,000-$120,000
    h. Over $120,000

Figure 5 shows the graphical design of the demographics survey. To move forward, users must answer all survey questions. If a user leaves the survey incomplete and goes to the next page, they will see an error forcing them to go back and complete the survey (Figure 6).

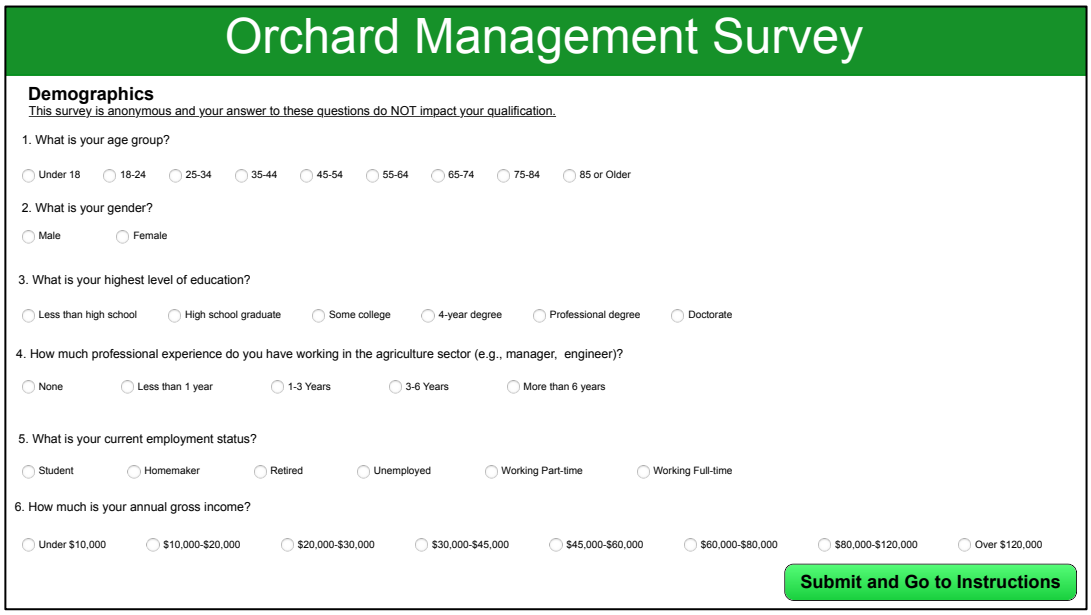

Figure 5. The demographics survey.

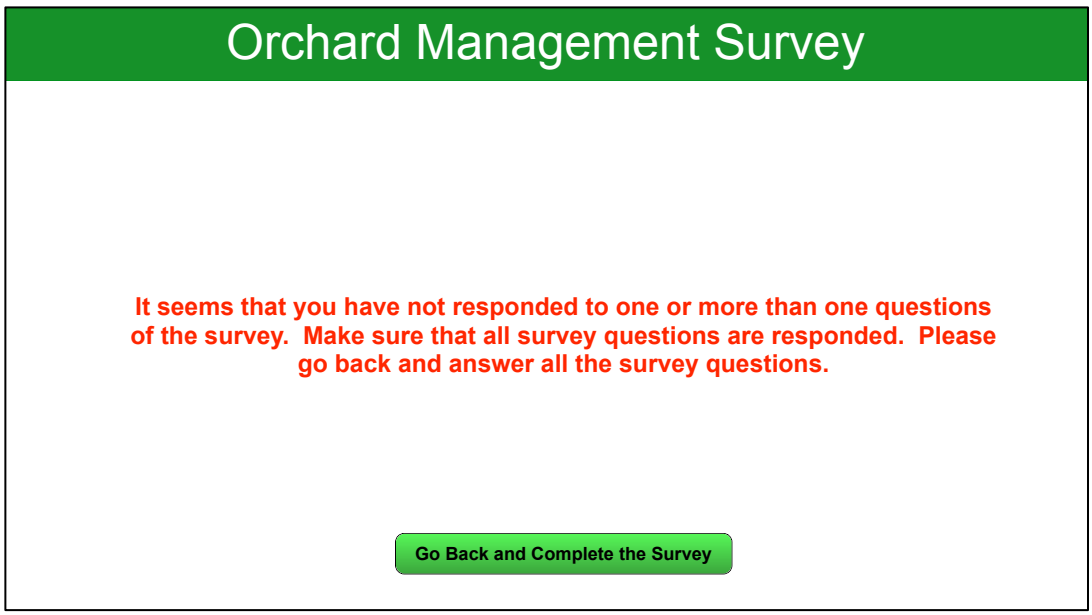

Figure 6. Users cannot move forward if they leave the survey incomplete

Experiment instructions

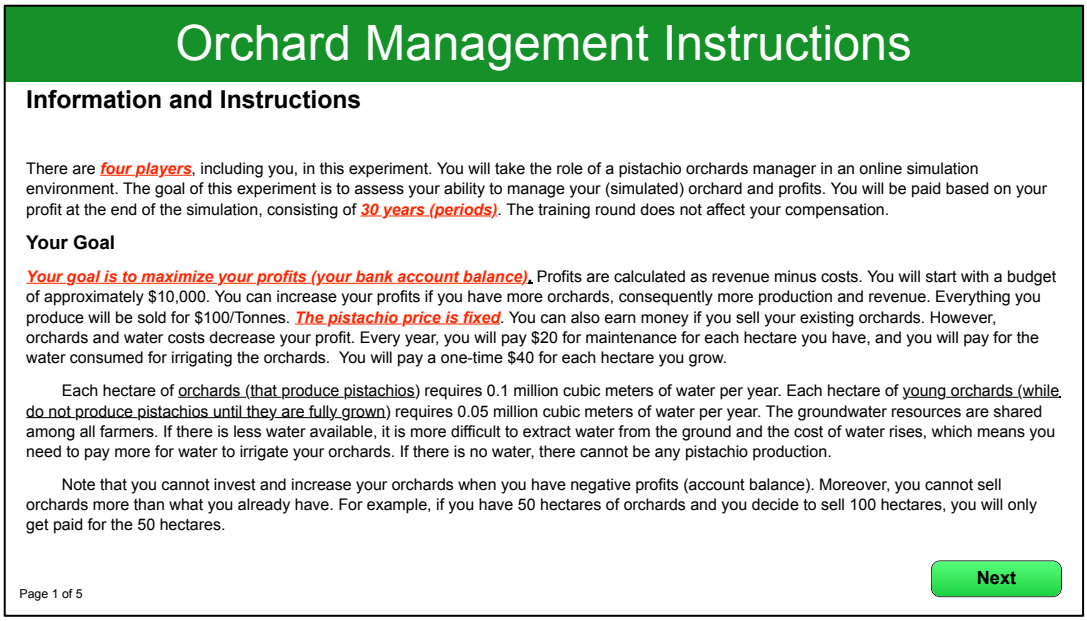

Figure 7. Information and instructions of the game

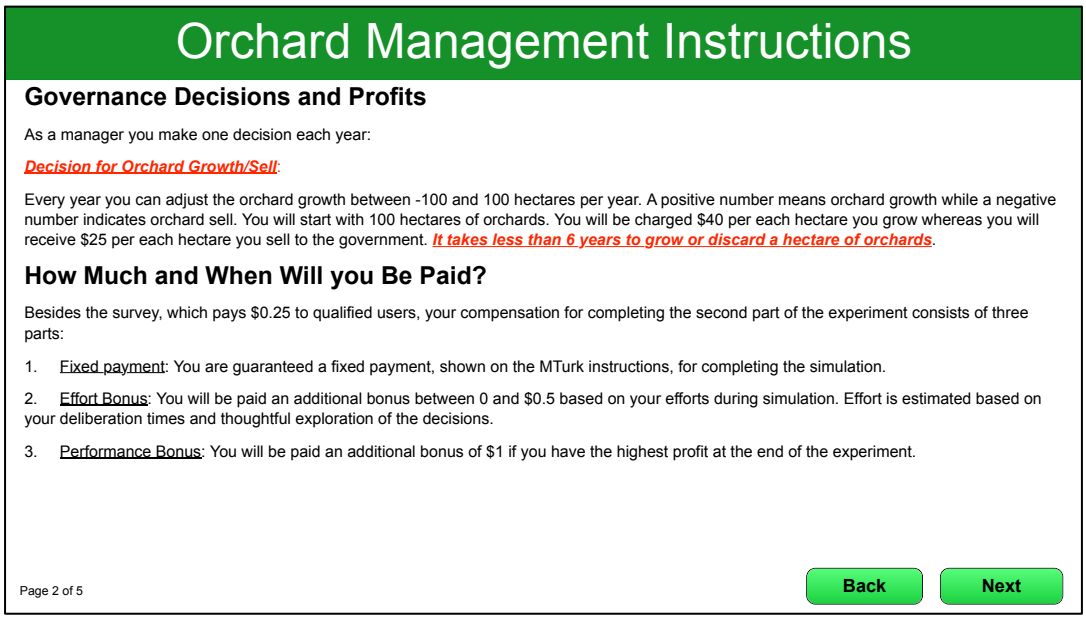

Figure 8. Further instructions and information about the incentives

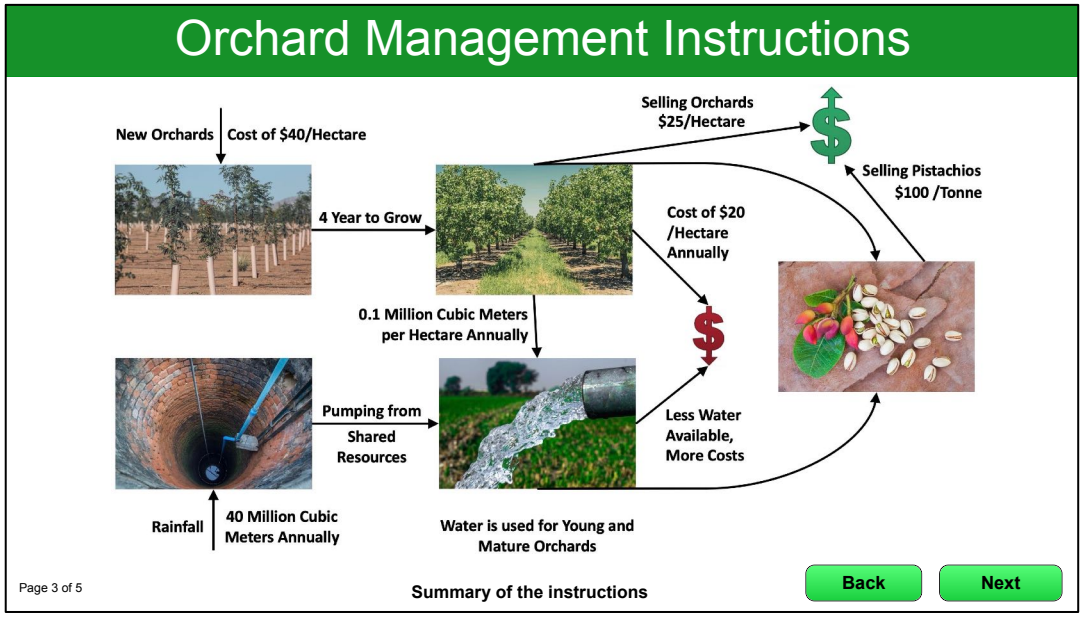

Figure 9. Summary of the instructions, visualized to provide a better overview

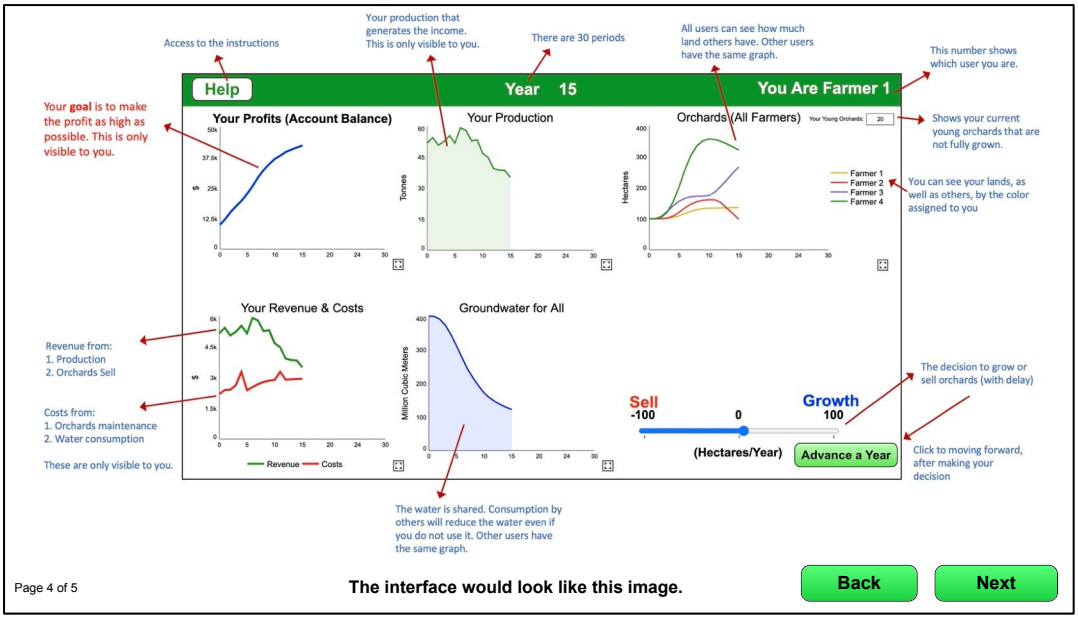

Figure 10. Interface instructions.

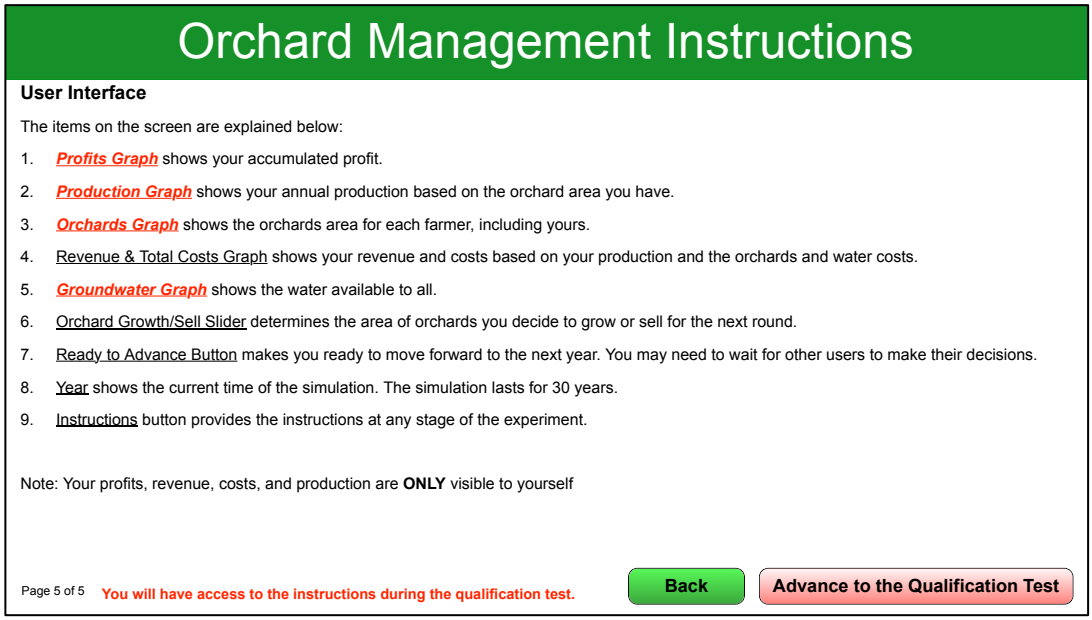

Figure 11. More information on the interface

Qualification test

We assess a subject's understanding of the experiment instructions using a few basic and very simple questions based on the instructions shown in the previous steps.

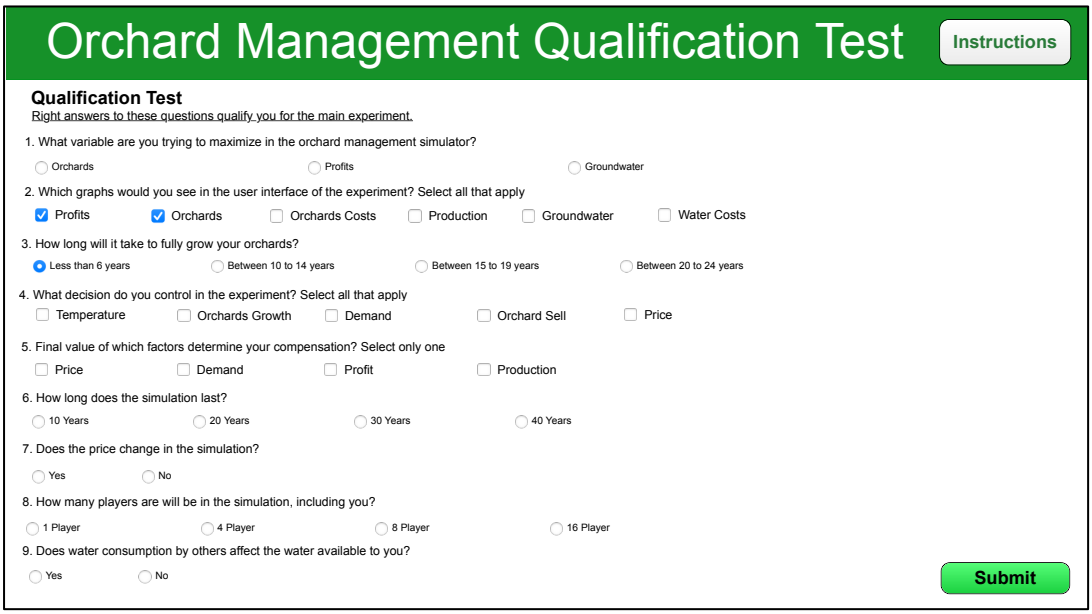

Figure 12. Qualification test

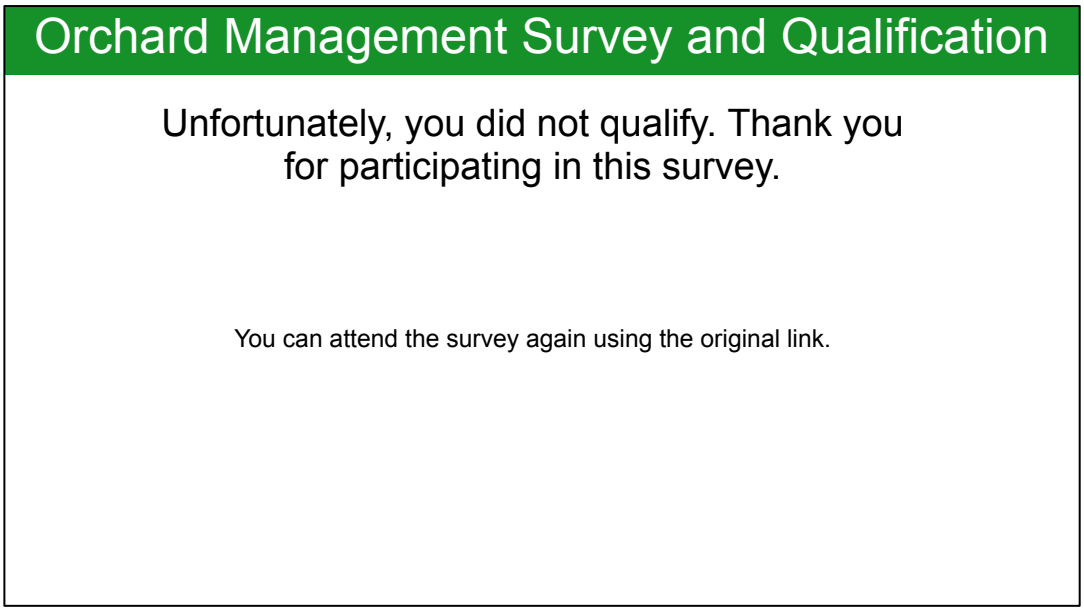

Figure 13. Message received by unqualified users

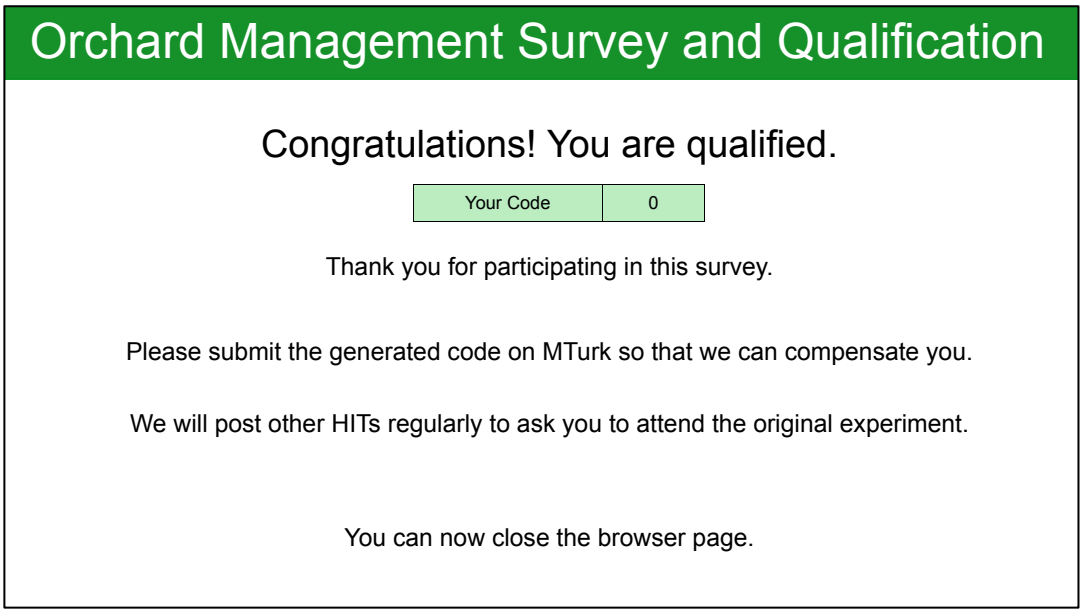

Figure 14. Survey code received by qualified users

Experiment Interface

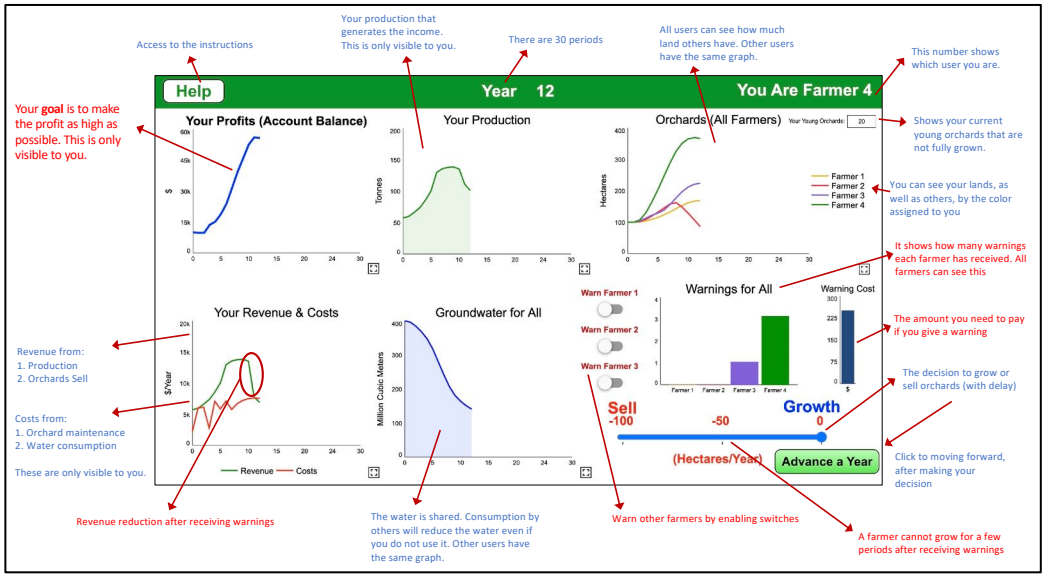

Figure 15. User interface with punishment

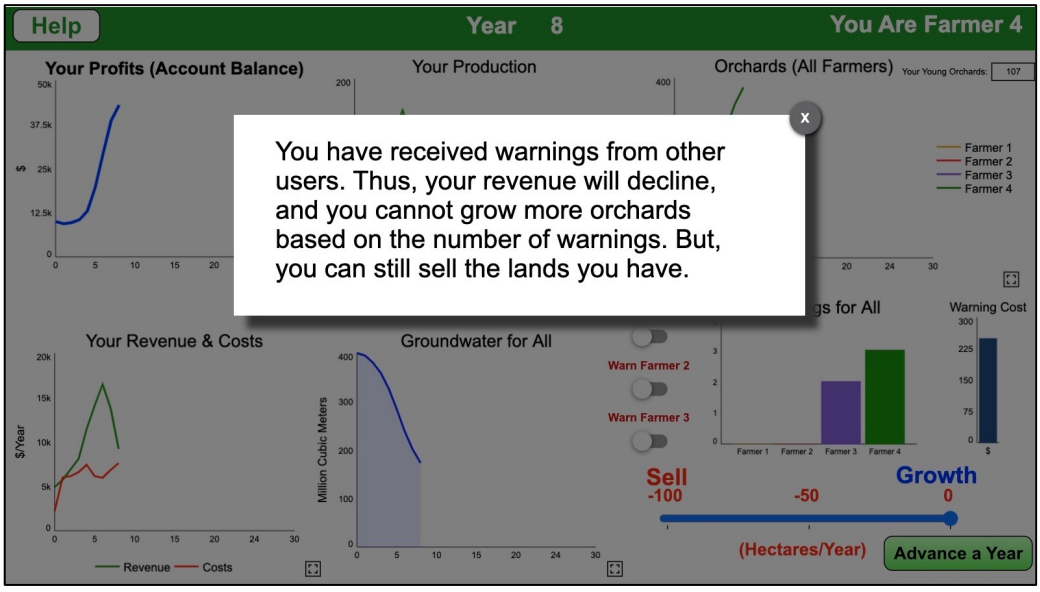

Figure 16. Message shown to a subject when their punishments received goes above the threshold

References

Tsur, Y., & Zemel, A. 2004. Endangered Aquifers: Groundwater Management Under Threats of Catastrophic Events. *Water Resources Research*, 40(6).