The EcoTrade Game

The environmentally friendly use of landscapes can be enhanced through certificate markets for land-use measures. After the implementation of such a certificate market in a region, the destruction of a habitat at one place is allowed only if a certificate can be provided that confirms the creation of an ecologically equivalent habitat elsewhere. If certificates can be freely traded a market for these certificates emerges that contributes to cost-effective conservation of biodiversity. The international EcoTRADE project (www.ecotrade.ufz.de) investigates the conditions under which a certificate market for conservation measures can work successfully.

A decisive factor for the survival of species is not only the availability of suitable habitat, but also that the species can move between individual patches of habitat. Therefore a constructed habitat patch is ecologically more valuable and earns more ecopoints if it is close to other habitat patches. This implies that market participants can influence each others’ actions – it is possible to cooperate and help each other, or not. How will the market participants behave?

To illustrate this game theoretic problem we implemented a certificate market in the form of an online* computer game in which each player takes the role of a land user. He or she can use his/her land for the production of ecopoints (biodiversity) or of conventional market (e.g. agricultural) goods. If the player produces more ecopoints than required by the conservation agency he can sell the overplus to other players. If he produces too few ecopoints he has to buy ecopoints from other players. The goal for each player is to maximise his profit by producing market goods as well as the sale of ecopoints. Winner of the game is who earns the most money.

The game was developed for the German Science Summer 2008 in Leipzig, from June 28 till 4 July, by Martin Drechsler¹, Florian Hartig¹ und Martin Horn².

¹ Department of Ecological Modelling, Helmholtz Centre for Environmental Research – UFZ, Leipzig
² Fachbereich Informatik, Universität Leipzig

* on request (to martin.drechsler@ufz.de) the game is also available for installation on a local network)
A. Short Guide

The objective for each player is to use his/her fields so that in the end of the game s/he has earned maximum profit on the land without harming the environment.

Each player possesses a number of fields which can be used either for agricultural production (brown fields) or for biodiversity conservation (green fields). The fields earn money (€) if they are brown, and ecopoints if they are green. Some fields are better suitable for agriculture than others (yellow bar and number). Ecopoints (green bar / white number) measure the ecological value of a field. Green fields that have many green neighbours create more ecopoints than isolated ones. You can also see the ratio of Euros and ecopoints by clicking on P/E below the game landscape.

Each player tries to earn a maximum of money on his brown fields. But watch out: you must not reduce your initial number of ecopoints. Before a player may turn a green field into a brown one (by clicking on it) s/he has to turn a brown field into a green field of at least the same ecological value (ecopoints) or buy ecopoints on the market.

But from whom can these ecopoints be bought? From another player who has more green fields than required and offers his ecopoints overplus on the market. One can therefore make money not only on the brown fields but also on the green ones!

Tip: By clever shifting green fields in the landscape and trading with ecopoints you can raise your profit!!

What you can do:

Always possible:
- Buying / selling ecopoints – On the lower right there is the trading window. Simply enter the desired number of ecopoints and the desired price (€/ecopoint) and press Buy or Sell – if there is another player who wishes to sell / buy ecopoints at this price the transaction takes place
- Chat function – To communicate with other players. Type in the message and press Ok.

Possibly only if it is your turn:
- Change green fields into brown ones or vice versa – but keep an eye on your ecopoints!
- Pass on to the next player – click on the “Ready” button below the game landscape

What you can see:

- Left – the game landscape: Green fields are ecological fields, brown fields are agricultural fields
- Upper right: The money (€) earned by yourself and the other players as well as the price of previous ecopoint transactions on the market
- Middle right: Chat messages and status of the game
- Lower right: Own and other players’ buy and sell orders on the ecopoints market

Have fun!
Detailed Guide

B. Preparation and start of the game

B1. To prepare the game go to http://www.ecotrade.ufz.de, choose menu item Software and click on EcoTRADE – The Game. The following applet appears:

After changing the language to English:
B2. Enter your name and
B3. Press the button „Create new game“.
The following window appears:
The fields and sliders have the following meanings:

a. Name = Name of the game
b. Width = Number of fields horizontally
c. Height = Number of fields vertically
d. Number of players = Number of players
e. Radius = Mobility range of the species to be conserved (1: to the nearest neighbouring field, 4: up to four fields). Habitat fields that lie within the mobility radius increase the ecological value of a habitat field.
f. Profit range = If the field is used for agriculture it earns a profit which lies within the range 50€ minus Profit range and 50€ plus Profit range.
g. Temporal correlation of agricultural profits. A value of 100% means that the profit in the next round equals that of the current round. A value of 0% means that the profit in the next round is a random number in the range specified under point f. If the temporal correlation is selected between 0 and 100%: the larger the correlation the more similar is the next round’s profit to the current one, the smaller the correlation the larger the random component in next round’s profit.
h. Neighborhood bonus = Relevance of neighbouring habitats. The amount of ecopoints earned by a habitat field is the sum of some base value and a neighbourhood value. The neighbourhood value is given by the sum of habitats located within the Radius around the habitat field (see point e) multiplied with the specified Neighborhood bonus. By choosing a high neighbourhood bonus the amount of ecopoints earned strongly depends on the number of habitat fields in the neighbourhood. By choosing a small neighbourhood bonus the number of habitat fields in the neighbourhood is relatively unimportant.
i. Initial number of habitats = Number of habitat fields for each player at the beginning of the game. This number determines whether the game landscape is of a natural (many habitat fields) or intensive agricultural (few habitat fields) type.
j. Time to move = Number of seconds during which a player has his/her turn to convert habitat fields into agricultural fields or vice versa. While land use can be changed only during a player’s turn ecopoints can be traded throughout the course of the game (cf. game schedule below).
k. Rounds per game = Number of rounds. Each player has his turn (point j) once per round.

B4. After pressing “Ok” you are back at the starting applet. There you can select the name of the game you want to join, enter your name and Press “Join the game”. If the specified number of other players has joined the game starts. If under point d (Number of players) the number 1 has been selected no other players are required but you play alone against the computer.
C Playing the game

The player’s objective in the game is to earn a maximum amount of money through agricultural production and/or the production and sale of ecopoints. How this works will be described below.

C1. The game landscape

On the picture one can see the game landscape with the fields. Brown fields are agricultural fields, green are habitat fields. Fields surrounded by a coloured line are your fields, the other fields belong to other players. Each of the player’s own fields contains a coloured bar with a green and a yellow part. The green part tells how many ecopoints the field produces if it is used as a (green) habitat field. The yellow part tells how many Euros the field earns if it is used agriculturally. The two numbers next to the bar provide the same information numerically.
Example: The field in the upper right belongs to the red player and is currently used as habitat (green). It produces 48 ecopoints. By clicking on this field the red player can (if it is his turn) convert it into an agricultural field. Then he produces 48 ecopoints less but earns 5 Euros more.

By clicking on the symbol P/E below the game landscape (standing for „profit/ecopoints“) the profit-ecopoint ratios are shown for all fields (in the example of the upper right field, the profit-ecopoints ratio is $P/E=6/48 = 0.125$ Euros per ecopoint). It is sensible to use fields with a high $P/E$ ratio for agriculture and fields with a low $P/E$ ratio for habitat and the production of ecopoints. By another click on NONE no numbers are shown in the fields at all. By a further click on P&E ecopoints and profits are shown again as it had been initially.

C2. The schedule of the game

To better understand the other functions of the game, the temporal structure of the game is explained. We distinguish between player rounds, game rounds and phases. A player round consists of phases. The last phase of a player round is what we called the player’s turn (cf. section B3, point j). In this phase, termed U phase, the player can change the use of his fields and/or trade ecopoints. In the preceding phases (called trading (T) phases) the player can only trade ecopoints. Since the players have their turn (U) one after another (and only one player at a time can have his turn), the number of phases per player round just equals the number of players in the game (except when one player plays against the computer: then a player round has one U phase and one T phase). The following table illustrates what has been described:

<table>
<thead>
<tr>
<th>Sp. 1</th>
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<tr>
<td>Sp. 2</td>
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<td>T</td>
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<tr>
<td>Sp. 3</td>
<td>U</td>
<td>T</td>
<td>U</td>
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It shows an example of three players. Player 1 begins his player round with two T phases where he can only trade ecopoints. The player round of player 1 ends with a U phase. The first player round of player 2 has only two phases: one T phase plus one U phase. The following player rounds of player 2 are complete (consisting of two T phases followed by one U phase), except for the final one. The first player round of player 3 has only one phase: a U phase. As one can see, the player rounds start asynchronously, always delayed by one phase.

In contrast to a player round, a game round ends when each player had his U phase once. In the example the game consist of three game rounds. These are identical with the player rounds of player 1. This identity of game round and player1 round, however, is not always found, since in the beginning of each game the sequence of the players is chosen by the computer programme randomly.
C3. Land use and player’s goal of the game

To simulate economic change in the game the agricultural profits $P$ of the fields can change in time (cf. Section B3, point g). This change happens simultaneously for all fields of a player: between the $U$ phase and the first $T$ phase, i.e. between two consecutive player rounds.

To assess the actions of the players, the profits of all fields of a player that are used agriculturally in the beginning of the player round are added up and shown above the game landscape. If the player decides to relax and do nothing this is the profit he earns in this player round.

Through clever play, however, the player can try to increase his profit. For instance, he can try to shift habitat from fields with high $P/E$ (profit/ecopoints) ratios to fields with low $P/E$ ratios: by converting habitat fields with high $P/E$ ratio into agricultural fields and agricultural fields with low $P/E$ ratio into habitat. In addition, the player can produce an overplus of ecopoints by creating more habitat fields and try to sell this overplus on the market (see section C5). At the end of the player round the clever player will have increased his profit (though the unadept player may reduce his profit), which he can observe in the profit shown above the game landscape.

In the middle above the game landscape the ecopoints overplus is shown, i.e. the difference between the number of ecopoints produced minus the number that has to be produced by regulation of the conservation agency. The latter number is determined by how many habitat fields there are in the beginning of the game (see point i in section B3) and is high if there are initially many habitat fields and low if there are only few habitat fields. This initial amount of ecopoints is however not relevant for the game. It is set to zero at the beginning of the game and must not fall below zero throughout the game. A player can therefore change a habitat into an agricultural field only if before he has created a sufficient overplus of ecopoints, either by creating a habitat of sufficient ecological value or by buying ecopoints (see section C5).

While the creation of a (positive) ecopoints overplus is possible, it is not per se an objective of the game! Creation of an ecopoints overplus has only to means: (a) the player wishes to change a habitat into an agricultural field and for this needs ecopoints as described above, or (b) the player sells the overplus on the ecopoints on the market (see section C5). The revenue of this sale is added to the player’s profit shown above the game landscape.
C4. The game status

As described in section C2, in each round the player earns a certain profit. These profits sum up over the player rounds in the course of the game. This growing total profit is shown in the left diagram. Specifically, the profit of the agricultural fields is counted once at the end of the U phase (cf. section C2) while profit changes due to purchase or sale of ecopoints are counted in the phase where the transaction occurs. In the diagram right to the total profit the ecopoint price is shown as it emerges from the market transactions (section C5) during the game.

The status window shows which player has his or her turn, and for all players once more their total profit in numerical format. To the right, players can communicate with each other via a chat function. Enter your message and click Ok.
C5. Der ecopoints market

If a player has created an ecopoints overplus and wishes to sell (part of) them he types in the number of ecopoints to be sold and the desired price (Euros per ecopoint). After pressing “Sell” the sale order appears in the order book on the right. Conversely, a player can buy ecopoints. Analogously, he types in the amount of ecopoints he wishes to buy, as well as the desired price, and presses “Buy”. The purchase order appears in the order book. If a player changes his mind and wishes to remove an order from the order book he can select it and press “Remove order”.

The orders in the order book are – similar to those at a stock market – permanently checked for whether a transaction is possible. If for instance a purchase order over 100 ecopoints at a desired price of 1 Euro per ecopoint meets a sale order over 50 ecopoints at the same desired price, 50 ecopoints change their owner at just this price (corresponding to a payment of altogether 50 Euros). If the seller demands a higher price than the buyer is willing to pay no transaction occurs. If the seller demands a lower price than the buyer is willing to pay, the electronic auctioneer in the program sets a “fair” price in the middle (so both market makers are happy: the seller gets a higher price than demanded and the buyers pays less than he would have been willing to).

The transactions are processed so that incoming orders are – if possible – immediately settled with existing orders which represents an “The early bird catches the worm” rule. If several suitable orders exist the incoming order is compared and settled first with the best of the existing ones. That means that if the incoming order is a purchase order the cheapest sale order is considered first and in the case of an incoming sale order the highest purchase order is considered first. If in this first transaction not all ecopoints of an incoming offer could be traded the next best order is taken, etc. If at the end of this process not all ecopoints of the incoming order could be traded the remaining ecopoints stay in the order book until the order is removed or settled with another incoming order.

As described, each transaction takes place at a certain market price (in the above example 1 Euro per ecopoint). These market prices are the above-mentioned ecopoint prices that are depicted next to the total profit (section C4). Such prices represent an important state variable of a market and provide helpful information for the players to formulate their orders (see below).

Purchased ecopoints have only a limited validity period. After purchase they are valid for the length of only one round. Consider for demonstration the example of section C2,
und assume player 1 buys from player 3 a number of 20 ecopoints at the time marked by the dashed line. This is just before the end of the first $T$ phase of player 1 and just before the end of the $U$ phase of player 3. The 20 ecopoints stay with player 1 until the time marked by the dotted line. This means that purchased ecopoints are valid until the end of the phase in which they have been purchased plus $N$-1 more phases, where $N$ is the number of phases per round (as explained, $N$ is also the number of players, i.e. $N$=3 in the example). So the purchased ecopoints are valid for $N$-1 phases plus part of a phase – rounded up altogether for the length of one round. At the very moment where the ecopoints expire for the player who purchased them the ecopoints are credited (“back”) to the player who sold them (i.e. player 3 in the example) (otherwise ecopoints would get lost in the course of the game which would be implausible).

Why do we give ecopoints a limited validity period? First, in the real world biodiversity conservation contracts usually have limited length, i.e. need to be renewed in certain intervals. Second, by setting the validity period to one round the price of the ecopoints is directly comparable with the $P/E$ ratios of the fields, which simplifies the players’ decisions to but ecopoints or create a habitat themselves.

For illustration assume in the above example that player 1 could purchase the ecopoints for the price of 1 Euro per ecopoint, but alternatively could produce them himself by creating a habitat of value $E$=20. Further assume that the agricultural field which is converted to habitat currently earns a profit of $P$=40 which means that this field has a $P/E$ ratio of $40/20$=2. Quite obviously it is for player 1 more economic to buy the 20 ecopoints from player 3, since this action costs him only 20 Euros while creating the habitat would cost him twice that amount. Exactly this can be seen already by comparing the ecopoint price of 1 with the fields $P/E$ ratio of 2: the field’s $P/E$ ratio is twice the ecopoint price on the market.

If we extended the validity period of ecopoints to several rounds the relationship between ecopoint price and $P/E$ ratio would be less direct, and instead the players would have to consider the validity period explicitly, which would complicate their decisions.

The limited validity period, however, has an important consequence: the ecopoints overplus can temporarily become negative without the fault of the player, which violates the basic assumptions of this game (and that of certificate markets)! How does this happen and how do we correct this?

Assume in the above example that at the time indicated by the dashed line player 1 had bought 20 ecopoints from player 3 and subsequently, with a clear conscience, destroyed a habitat of value $E$=20, obtaining on net an ecopoints overplus of zero in that player round. At the time indicated by the dotted line, however, the 20 purchased ecopoints expire and player 1
starts into his new player round with a ecopoint deficit of 20. He has now two possibilities to balance his ecopoints account: either buy again 20 ecopoints, or in the next U phase create a habitat with value of at least $E=20$.

The rule of the game is now that by the end of the U phase the ecopoint overplus must be zero or positive. If a player misses to balance is ecopoint account by this time the computer programme creates habitat fields on his land until the ecopoints overplus is zero or positive. This is done at an increasing $P/E$ ratio, i.e. first the agricultural field with the lowest $P/E$ ratio is converted into habitat, then the agricultural field with the next smallest $P/E$ ratio, and so on.