Chapter 3

Saving the Commons: A Simulation for Understanding the Need for Collaboration to Resolve Environmental Issues

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Contents

Student Outline

Introduction to the Kivulini Simulation

Background

You and your team members comprise the top management team of a sizable manufacturing facility in Kivulini -- a country that is expected to experience rapid industrialization because of its abundant resources, low wage structure, and loose regulations.

You and your team are somewhat troubled because you know that the financial performance of your plant has been discussed at headquarters (in another country), and they have quite bluntly informed you that they expect higher returns on their invested capital. You are uncertain about whether the plant will be closed if your plant's profitability doesn't improve, but you are *quite sure* that your own compensation and career track in the company are related to the financial performance of the plant. Currently, your team has 100 pazos – the currency of Kivulini-- in uncommitted funds.

Your plant, along with a number of other plants, is located on a large inland freshwater lake, Lake Gunoi, upon which there are two cities (Porto Deano and Mji ya Ian) with a combined population of about 200,000 people. Importantly, all of the plants (and the cities) desire a continuous, unpolluted source of water for their manufacturing processes (and quality of life, as all of you live nearby the lake). Currently, while water quality has deteriorated noticeably in the last few years, the water is still acceptable. The lake has a restricted outlet and does replenish itself, but within limits.

Unfortunately, while each industry needs a good source of water, each one releases a number of toxic pollutants into the lake. Currently, neither the national nor the local governments regulate either the amount of water taken from the lake or the amount of waste released into the lake. Consequently, the condition of the lake is determined mainly by the industries themselves.

Problem

In sum, the problem facing you as a plant management teams is, "How do we profitably operate our plant when our process is dependent on the lake as a common resource?"

Rules

1. You may talk freely to the other managers in your plant, but do not talk to managers from other plants unless given explicit permission.
2. Stay on the same round as everyone else.
3. Fill in all the information of your tally sheet or Profit/Loss (P/L) worksheet.

Procedure

You will be confronted with a series of decision opportunities each round in which you must choose a course of action regarding your use of the lake water.

For the first seven rounds:

Your management team may choose among the following three strategies for the first seven rounds:

1. RED -- You continue to use the lake water as you've always used -- discharging byproducts into the lake. RED choices will cause degradation of water quality. The financial outcome of this choice depends on how many other plants choose this strategy. Of course, RED degrades the water quality. If a single company chooses RED and all others choose BLACK, then the RED company can be a "free rider" by benefiting the most from a cleaner lake without having to bear any costs of cleaning the lake. Your profits also depend upon the quality of the lake water. If the water quality deteriorates, all plants' production processes will suffer. If water quality improves, all plants will benefit.

2. BLACK -- Recognizing the deterioration of the water quality, you limit pollution into the lake by storing it, treating it, cutting back on production, or subcontracting its removal. BLACK neither degrades nor improves water quality. Water can only be improved by natural processes (*i.e.*, flushed out by heavy rains which occur once every four rounds). The financial outcome of this choice depends on how many other plants choose this strategy. For example, if all plants choose BLACK, every plant will benefit by having cleaner water. If only one company chooses BLACK and everyone one else chooses RED, then the company choosing BLACK would incur lake cleaning costs without any real benefit. Your profits also depend upon the quality of the lake water. If the water quality deteriorates, all plants' production processes will suffer. If water quality improves, all plants will benefit. Should the opportunity present itself to discuss this problem with other plant managers, choosing BLACK implies compliance with any agreements or understandings to reduce levels of pollution in the lake.

3. YELLOW -- You take unilateral, technical measures to make your process less dependent on lake water and, as a result, less dependent on the actions of the other plants. To develop these technical measures, you spend 20 units of currency on research and design (R&D). You can choose YELLOW only once. Three rounds after you invest in the yellow strategy, you will earn 2 units of currency for each round for the remainder of the simulation. The company incurs cost for R&D initially, but after it has been implemented, R&D pays off.

Financial Outcomes:

Each choice has financial outcomes. For RED and BLACK, the financial outcome depends on how many plants used these approaches. For example, if all plants on the lake limit their pollution (by choosing BLACK), then every plant will benefit from having cleaner water. However, if a single plant reduces its pollution while others continue to pollute (by choosing RED), then that single plant would incur the cost of

reducing pollution with little benefit. Conversely, if all but one plant reduces their pollution by choosing BLACK, the one rogue plant that continues to pollute by choosing RED will accrue benefits from being a "free rider."

In addition to being dependent on the pattern of choices, payoffs are also dependent on the quality of the water. Of course, as the water quality deteriorates, all plants' production processes will suffer. Conversely, as water quality improves, all benefit.

Status of the lake:

The status of the lake will be shown by the location of a marker on the backboard. The marker will move up or down as the status (water quality) of the lake changes. RED choices cause a degradation of water quality, while BLACK choices neither degrade nor improve water quality. The facilitator will move the peg down one unit for each red choice. Water quality is only improved by natural processes; the lake water is flushed out by the annual, and often heavy spring rains. Every four rounds the peg will be moved up ten units as a consequence of the natural restoration of the lake.

Payoffs:

These two influences (the number of plants polluting and water quality) are incorporated into different payoff matrices. The payoff matrix will be changed as the water quality changes.

Indicating your choice:

Your management team will indicate your choice when the facilitator comes by your plant (point to the color of your choice). The simulation will continue until it is terminated by the instructor.

For the eighth and subsequent rounds:

Your management team may choose from among the following seven options for the eighth and subsequent rounds:

1. RED -- You continue to use the lake water as you've always used -- releasing toxic byproducts into the lake. See above explanation.
2. BLACK -- Recognizing the deterioration of the water quality, you limit pollution into the lake (*e.g.*, by storing it, treating it, cutting back on production, or subcontracting waste removal). Should the opportunity present itself to discuss this problem with other plant managers, choosing BLACK implies compliance with any agreements or understandings to reduce levels of pollution in the lake.
3. YELLOW -- You take unilateral, technical measures to make your process less dependent on lake water and, as a result, less dependent on the actions of the other plants. This option may be taken only once by each company during the entire simulation.
4. BLUE/RED -- You expend financial resources to enable a third party or agency to institute fines for polluters (teams that picked RED) in that round. *In addition, your own plant continues to use the lake water, releasing toxic byproducts into the lake.* In particular, you spend 3 pazos to hire a third party or agency to institute fines for polluters. Those plants that chose RED during this round will get fined if they get caught. The fine for plants that get caught is -5 pazos. A roll of a die determines if you get caught or not (1=caught). Plants who get caught will be publicly admonished. If more than 2 teams choose blue, the die will be rolled that many times.
5. BLUE/BLACK -- You expend financial resources to enable a third party or agency to institute fines for polluters in that round. *In addition, your own plant limits its pollution into the lake.* In particular, you spend 3 pazos to hire a third party or agency to institute fines for polluters. Those plants that chose RED during this round will get fined if they get caught. The fine for plants that get caught is -5 pazos. A roll of a die determines if you get caught or not (1=caught). Plants who get caught will be publicly admonished. If more than 2 teams choose blue, the die will be rolled that many times.

6. ORANGE/RED -- You expend financial resources to enable an association to reward the most cooperative team on this round (*i.e.*, the team that has chosen BLACK the most often). *In addition, your own plant continues to use the lake water, releasing toxic byproducts into the lake.* In particular, you spend 3 pazos to enable an association to reward the most environmentally conscious company. The plant having chosen BLACK the most times as of this round will get rewarded. The reward is +5 pazos plus a "green award" prize. Ties will be resolved by a toss of a coin.
7. ORANGE/BLACK -- You expend financial resources to enable an association to reward the most cooperative team on this round (*i.e.*, the team that has chosen BLACK the most often). *In addition, your own plant limits its pollution into the lake.* In particular, you spend 3 pazos to enable an association to reward the most environmentally conscious company. The plant having chosen BLACK the most times as of this round will get rewarded. The reward is +5 pazos plus a "green award" prize. Ties will be resolved by a toss of a coin.

Rules

1. Each company has 100 pazos not already committed for other use.
2. All companies around Lake Gunoi release toxic substances into the lake.
3. All companies' processes depend on clean water.
4. Currently there are no regulations regarding pollutants into the lake.
5. You may talk with those in your company but not to people from other companies unless told to do so.
6. You have 3 choices in the 1st 7 rounds: red, black, and yellow.
7. Payoff after each round is dependent on the number of plants polluting and water quality of the lake after each round (see payoff matrices).
8. Water quality status of the lake will be displayed after each round.
9. Payout for each round is determined by the lake's water quality after selection of your strategy.
10. Rains will increase water quality 10 units after every 4th round (yearly rains). Use 5 units if a 2-hour class, which signifies a drought.
11. Each company may not have less than –50 pazos. If the balance goes below –50 pazos, the company will be closed pending review.
12. After round 7, all companies will have a conference together. During the conference, the managers may increase payoffs, or place additional pressure to come up with a solution.
13. After the conference, two new choices are available:
    - Blue: spend 3 pazos to hire an agency to police the water quality and fine polluters.
    - Orange: pay 3 pazos to provide a reward (+5 pazos) to the most environmentally conscious company, the one that has chosen black the most times.
14. Red: Business as usual, dumping byproducts into the lake – causes degradation of water quality.
15. Black: Limit pollution by treating water or subcontracting waste removal.
16. Yellow: Unilateral measures to decrease pollution. Pay 20 pazos one time to develop R&D. After 3 rounds, you get 2 pazos each round. May choose this only once.

Team's Profit/Loss Worksheet

Team members: _____

Round / Quarter	Strategy Choice (color or colors)	Payoff from Strategy	Adjustments (ROI, one-time costs, penalties)	Total for this round	TOTAL Cumulative Pazos
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

Use back for additional Rounds

Costs and Earnings Schedule (Effects of Choices)

Color	Earnings/costs for Team	Consequences for Other Plants	Lasting Effects
Red	See Payoff Matrix	--	Reduce water quality
Black	See Payoff Matrix	--	Does not improve or degrade water quality
Yellow	-20 Pz	--	+2 Pz each round to Team starting 3 trials after investment
Blue	-3 Pz	"Red" plants –5 Pz fine (if caught)	--
Orange	-3 Pz	Most exemplary plant +5 Pz	--

Notes for the Instructor

This exercise is based on "The Tragedy of the Commons" by Garrett Hardin, a classic article on the use of shared resources published in Science in December 1968. The simulation was created by Dr. Robert S. Dooley of Oklahoma State University and Gerald Fryxell of The Hong Kong Polytechnic University, both in the Management Departments of their respective universities. It demonstrates the role of collaboration and trust in solving environmental problems.

There is much concern about the impact of industrial pollution on the quality of our air and water, as well as the damage to our forests through acid rain. These are shared resources for all our citizens, and a decrease in any of these diminishes the quality of all of our lives. These shared resources are actually shared commons, available for all to use, or abuse. Our nation has many such commons, including the national parks, grazing lands in the west, wildlife reserves, watersheds, and the air above us.

Virginia Tech uses this exercise in the freshman biology lab class as an ecology exercise in an effort to give them some information on issues of importance to their lives; issues for which they will have to find solutions in the years ahead.

The exercise uses between five and eight groups of students as managers of different industries that border on a lake and use the water resources of the lake. The profits are directly related to the quality of the water available in the lake, but each industry also releases a number of toxic pollutants into the lake. These companies chose to locate their plants at this location because the country, Kivulini, does not have any regulations on how much or what type of waste is dumped into the lake. The problem for each group of students is how to profitably operate their industrial plant when the process is dependent on the lake as a common resource shared by other industries and the community.

This exercise clearly demonstrates that industries have to cooperate with each other and with the town affected by the industries in order to maintain a clean water resource so that all companies may make a profit over the long term, and provide a safe and healthful environment in which all stakeholders live. It also demonstrates the basic problems of cost and profitability that companies must deal with in addition to environmental concerns. Role-playing as industry managers makes the corporate decision making process more realistic.

Though this exercise was developed for business classes, it is important for idealistic biologists and students to understand how companies operate and what motivates big business, in order that they can effectively work with companies to gain their own goals of a cleaner, more stable environment.

Objectives of this exercise are:

- to lead students to conclude for themselves the importance of collaboration and trust in solving problems related to the commons, and
- to experience the realities of business practices and how they affect the commons areas.

This exercise may be used at all instructional levels and is broadly applicable to a variety of courses as it focuses on ethics and collaboration to resolve the issue of pollution at a specific site. Introducing this exercise to the class takes a bit of time upfront. It is important to run through a few example rounds so the students get a feel for the mechanics of the simulation. It is a good idea to have students read the "Tragedy of the Commons" by Garrett Hardin prior to the day of the simulation. It is suggested that the page of Rules be handed out to the class so they have them in front of them the entire time and also a page with example rounds and the tally sheet that correspond to the example rounds.

Preparation time is probably less than an hour the first time it is done. Folders and awards and signs to announce the conference are props to make the scenario a bit more realistic (see Appendix A). Folders do not need to be elaborate; they can be simple sheets of folded paper with the words red, yellow, blue, etc. written on them.

The instructor records the choices made for each round by each industrial company, and the instructor also keeps track of the water quality at the end of each round. Students keep track of the financial status of

their company. Cumulative scores for the companies can go negative down to –50 pazos. Companies with cumulative balances less than –50 pazos will be closed down pending a review of their financial viability.

Once the yellow option is used, it cannot be used again, +2 Pazos should be added in the column "adjustment" beginning with the third round after the yellow option is chosen.

After round number 7, all plant managers will have a conference. At the conference, managers may decide to double the payoffs (a function of the number of companies polluting and water quality) or place additional pressure on teams to devise a solution. After the conference, you can continue to choose from the above three options or choose from the two following options for a total of 5 choices.

As the simulation progresses, should the managers decide they need another conference, they may call for another one. The instructor may suggest they have a mediator to help them resolve issues. Perhaps the penalty (and therefore the cost) should be higher for hiring a third party to monitor the water quality, but all those choosing RED get caught.

If you would like an electronic copy of any of the tables or tally sheets to use in your classes, please email me at *mschaeff@vt.edu.*

Guidelines for Making Folders and Using the Tally Sheet

Folders may be made to keep decision-making secret. The folders we use are manilla file folders with 2-inch square pieces of colored paper pasted to the inside. The colors are yellow, red and black for the first seven quarters of the simulation. The second row of colors is a combination of black and blue, red and blue, orange and blue, and orange and red. These may just be written inside the folder. We use the folders so the managers of the companies can point to their strategy for the next quarter without saying it out loud.

A sample of the scoring for each quarter is as follows:

Water quality is at "0" at the beginning of the game. When the managers all decide on their strategy for the first round, the tally sheet would look like the first row shown below:

Round 1		Round 2		Round 3	
Group 1	Yellow	Group 1	Black	Group 1	Black
Group 2	Black	Group 2	Yellow	Group 2	Black
Group 3	Red	Group 3	Red	Group 3	Red
Group 4	Red	Group 4	Red	Group 4	Red
Group 5	Red	Group 5	Red	Group 5	Red
Group 6	Black	Group 6	Red	Group 6	Black

Instructor Tally Sheet

Remark	round	1	2	3	4	5	6	black	red	yellow		Blue	OR	WQI
	1	Y	B	R	R	R	B	2B	3R	1Y				-3
	2	B	Y	R	R	R	R	1B	4R	1Y				-7
	3	B	B	R	R	R	B	3B	3R	0Y				-10

Determining the payoff after each round

The water quality determines the payoff matrix used (see Appendix B for payoff matrices). After the first round, decisions are made, with each company pointing to the color denoting their strategy, and the water quality in the example decreases to –3 because three companies chose red. The payoff matrix -3 in the set of tables included, which corresponds to the water quality, indicates that each team that chose black (there were two of them) will lose 4 pazos for that first round. Those teams who chose red (there were 3 of them) will gain +5 pazos each. Payoff for round 2 would be on the –7 Water Quality Matrix. The number of companies choosing black for round 2 is one, with a payoff for that company being –9 pazos. The number of companies choosing red is 4. Their payoff is –4 pazos for each company. For round 3, the water quality is –10 and index used is –10. The number of companies choosing black is three, so the payoff for those companies is –10. The number of companies choosing red is three, so the payoff for companies choosing red is –6. If a team chooses yellow in a round, then it does not get a payoff from the payoff for that round.

After a conference is held to try to garner cooperation between the companies to maintain water quality, the orange and blue choices may become available along with the red, black and yellow choices if the consensus of the companies is to institute those choices. Of course, yellow may only be chosen one time during the entire game for each company.

Instructor Tally Sheet

Remark	Round	1	2	3	4	5	6	Black	Red	Yellow		BL	OR	WQI
BK,R,Y	1													
	2													
	3													
	4													
Rain before P/L, appeal	5													
	6													
	7													
Conf, OR &BL opt.	8													
Rain before P/L, appeal	9													
	10													
	11													
	12													
Rain before P/L, appeal	13													
	14													
	15													
	16													
Rain before P/L, appeal	17													
	18													
	19													
	20													
Rain before P/L, appeal	21													

P/L - Settle Profit/Loss accounts

Discussion Guide for the Simulation

The Commons Problem

Whenever disassociated actors share a common resource, in the presence of development and in the absence of mutually coercive mechanisms, they are doomed to ruin it (Garrett Hardin, 1968). Other commons are land, air, water, biodiversity and space. Some discussion points are listed below:

- Many problems faced by organizations are commons problems.
- A technical solution is not enough to solve the problem; values and morals must come to play in order to achieve an optimal solution.
- Devising successful solutions is beyond the ability of any one organization and, thus, requires collective action.
- In the long run, competitive behavior can be less profitable than collaboration.
- Trust is a key factor in enabling collaboration.
- There are a number of approaches for dealing with the commons problem, and some are better than others. Some of the less desirable approaches will be imposed in the absence of more effective ones.
- Managers must consider the extended consequences of their actions.
- Corporations impact the natural environment in a number of ways: population; deforestation; water, air, and land pollution; loss of biodiversity, etc.

There are benefits to collaboration and trust in developing collective solutions.

Organizations acting independently in their own interests may produce unintended consequences that are detrimental in the long run for themselves and for others. Firms should collaborate with other firms and stakeholders so as to meet both the goals of the firm and stakeholder needs.

- Collaboration requires a broader understanding of the problem, and participants must realize their interdependence.
- Collaborative action can occur either voluntarily or be mandated from an external source such as government.
- Successful collaboration requires constructive behaviors among participants such as open communication and exchange of ideas, greater perceived influence by all participants, and a willingness to search for alternative courses of action among different solution sets.
- Mutual trust is essential. A lack of trust created by irresponsible firms undermines many well-intentioned initiatives.
- Trust decreases both perceptions of risk and vulnerability and encourages cooperative behavior.

What did this simulation teach us?

- The importance of the impact of corporations on the natural environment. Impacts include overpopulation, global warming, ozone depletion, deforestation, air & water pollution, loss of biodiversity, etc.
- Dealing with these challenges will require a different set of values than the ones we have been relying upon; managers must realize the importance of considering the extended consequences of their actions; and there are benefits to collaboration and trust in developing collective solutions to many problems.
- Organizations acting independently in their own best interest often produce unintended consequences that are detrimental in the long run for themselves and others.
- Stakeholders must be considered in decision-making. Firms should collaborate with other firms and stakeholders so to meet both firm specific goals and stakeholder needs.
- Collaboration creates a broader understanding of the problem, resulting in a mutual synergy.

- Collective action requires that participants recognize their interdependence and believe that positive outcomes will result from collaborative efforts. Collective action can occur voluntarily or a mandate from an external source (i.e., government) may be necessary to evoke it.
- Successful collaboration requires constructive behaviors among participants such as open communication and exchange of ideas, greater perceived influence by all participants, and a willingness to search for alternative courses of action among different solution sets. Mutual trust is essential. A lack of trust created by irresponsible firms undermine many well-intended initiatives. Trust mitigates perceptions of both risk and vulnerability and engenders cooperative behavior.

Questions to consider:

- What are some of the biological implications of this scenario?
- What are all the various stakeholders of this simulation?
- Where might this type of scenario be occurring today? Who are the stakeholders in that situation and what are their concerns?
- What can we do to increase the likelihood of a positive outcome for the environment?
- Which groups' concerns are not being considered in this scenario?
- When plants operate independently with strong pressures to gain profitability, the water quality will deteriorate. Why did this happen? (Because benefits accrue individually, but costs are shared.)
- Does the morality of an action change with the scarcity of a resource? What was your reaction to the government's plea for consciousness? (Those that complied most likely felt like fools because so many others ignored it; so because they did not feel like good citizens, they probably vowed not to follow government pleas in the future.) Are any pleas for voluntary restraint currently being made? Do any involve a common resource?
- What does it mean to be "green?" What did the colors mean? (red=win/lose competition; black=win/win collaboration; blue=punishment relies on a third party/government control; orange=reward relies on a third party/government control; yellow=independent technical solutions)
- What is the role of leadership, trust and collaboration when dealing with a commons problem?
- What other solutions exist to save the commons?

Literature Cited

Fryxell, G. E., and R. Dooley. 1997. Saving the Commons: A behavioral simulation for experiencing the role of collaboration and trust in devising workable solutions to environmental and other social issues. Research in Corporate Social Performance and Policy, Supplement 2, 149-183. JAI Press Inc. ISBN 0762302895.

Hardin, G. 1968. The tragedy of the commons. Science, 162: 1243-1248.

APPENDIX A

Here is an example (reduced in size) of the award certificate we use:

LAKE GUNOI ENVIRONMENTAL PERFORMANCE AWARD

Here is an example (reduced in size) of the conference announcement:

CONFERENCE ON LAKE GUNOI CLEANUP

COMING APRIL 23rd

MEETING TO BE HELD IN

DERRING 1009

DISCUSSIONS OF TOXICITY LEVELS AND HARMFUL EFFECTS TO PEOPLE AND WILDLIFE
OPEN FORUM ON REDUCING POLLUTION OF THE LAKE

APPENDIX B

Tables for determining payoff after each round

For Water Quality 0

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-2	1	+10
2	-1	2	+9
3	0	3	+7
4	+1	4	+6
5	+3	5	+4
6	+5	6	+3

For Water Quality -1

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-3	1	9
2	-2	2	8
3	-1	3	7
4	0	4	5
5	2	5	4
6	4	6	3

For Water Quality -2

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-4	1	8
2	-3	2	7
3	-2	3	6
4	-1	4	4
5	0	5	3
6	2	6	1

For Water Quality -3

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-5	1	8
2	-4	2	6
3	-3	3	5
4	-2	4	3
5	-1	5	1
6	1	6	-1

For Water Quality -4

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-6	1	6
2	-5	2	5
3	-4	3	3
4	-3	4	1
5	-2	5	-1
6	0	6	-2

For Water Quality -5

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-7	1	5
2	-6	2	3
3	-5	3	2
4	-4	4	0
5	-3	5	-2
6	-1	6	-4

For Water Quality -6

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-8	1	3
2	-7	2	1
3	-6	3	0
4	-5	4	-2
5	-4	5	-4
6	-2	6	-5

For Water Quality -7

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-9	1	2
2	-8	2	0
3	-7	3	-2
4	-5	4	-4
5	-4	5	-6
6	-3	6	-7

For Water Quality -8

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-10	1	0
2	-9	2	-2
3	-8	3	-4
4	-6	4	-6
5	-5	5	-7
6	-4	6	-8

For Water Quality -9

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-11	1	-1
2	-10	2	-3
3	-9	3	-5
4	-7	4	-7
5	-6	5	-8
6	-5	6	-9

For Water Quality -10

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-12	1	-2
2	-11	2	-4
3	-10	3	-6
4	-8	4	-8
5	-7	5	-9
6	-6	6	-10

For Water Quality -11

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-13	1	-4
2	-12	2	-6
3	-11	3	-8
4	-9	4	-10
5	-8	5	-12
6	-7	6	-14

For Water Quality -12

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-14	1	-5
2	-13	2	-7
3	-12	3	-9
4	-10	4	-11
5	-9	5	-13
6	-8	6	-15

For Water Quality -13

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-15	1	-6
2	-14	2	-8
3	-13	3	-10
4	-11	4	-12
5	-10	5	-14
6	-9	6	-16

For Water Quality -14

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-16	1	-7
2	-15	2	-9
3	-14	3	-11
4	-12	4	-14
5	-11	5	-16
6	-10	6	-18

For Water Quality -15

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-17	1	-8
2	-16	2	-10
3	-15	3	-12
4	-13	4	-15
5	-12	5	-17
6	-11	6	-19

For Water Quality -16

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-18	1	-9
2	-17	2	-11
3	-16	3	-13
4	-14	4	-16
5	-13	5	-18
6	-12	6	-20

For Water Quality -17

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-19	1	-10
2	-18	2	-13
3	-17	3	-16
4	-15	4	-19
5	-14	5	-22
6	-13	6	-25

For Water Quality -18

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-20	1	-11
2	-19	2	-14
3	-18	3	-17
4	-16	4	-20
5	-15	5	-23
6	-14	6	-26

For Water Quality -19

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-23	1	-12
2	-22	2	-15
3	-21	3	-18
4	-19	4	-21
5	-18	5	-24
6	-17	6	-27

For Water Quality -20

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-25	1	-13
2	-24	2	-16
3	-23	3	-18
4	-21	4	-22
5	-20	5	-25
6	-19	6	-28

For Water Quality +1

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	-1	1	11
2	0	2	10
3	1	3	8
4	2	4	7
5	4	5	5
6	6	6	4

For Water Quality +2

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	0	1	12
2	1	2	11
3	2	3	9
4	3	4	8
5	5	5	6
6	7	6	5

For Water Quality +3

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	1	1	13
2	2	2	11
3	3	3	9
4	4	4	7
5	6	5	6
6	8	6	5

For Water Quality +4

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	2	1	14
2	3	2	13
3	4	3	11
4	5	4	10
5	7	5	8
6	9	6	7

For Water Quality +5

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	3	1	15
2	4	2	14
3	5	3	12
4	6	4	11
5	8	5	9
6	10	6	8

For Water Quality +6

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	4	1	16
2	5	2	15
3	6	3	13
4	7	4	12
5	9	5	10
6	11	6	9

For Water Quality +7

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	5	1	17
2	6	2	16
3	7	3	14
4	8	4	13
5	10	5	11
6	12	6	10

For Water Quality +8

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	6	1	18
2	7	2	17
.3	8	3	15
4	9	4	14
5	11	5	12
6	13	6	11

For Water Quality +9

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	7	1	19
2	8	2	18
3	9	3	16
4	10	4	15
5	12	5	13
6	14	6	12

For Water Quality +10

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	8	1	20
2	9	2	19
3	10	3	17
4	11	4	16
5	13	5	14
6	15	6	13

For Water Quality +11

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	9	1	21
2	10	2	20
3	11	3	18
4	12	4	17
5	14	5	15
6	16	6	14

For Water Quality +12

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	10	1	22
2	11	2	21
3	12	3	19
4	13	4	18
5	15	5	16
6	17	6	15

For Water Quality +13

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	11	1	23
2	12	2	22
3	13	3	20
4	14	4	19
5	16	5	17
6	18	6	16

For Water Quality +14

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	12	1	24
2	13	2	23
3	14	3	21
4	15	4	20
5	17	5	18
6	19	6	17

For Water Quality +15

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	13	1	25
2	14	2	24
3	15	3	22
4	16	4	21
5	18	5	19
6	20	6	18

For Water Quality +16

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	14	1	26
2	15	2	25
3	16	3	23
4	17	4	22
5	19	5	20
6	21	6	19

For Water Quality +17

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	15	1	27
2	16	2	26
3	17	3	24
4	18	4	23
5	20	5	21
6	22	6	20

For Water Quality +18

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	16	1	28
2	17	2	27
3	18	3	25
4	19	4	24
5	21	5	22
6	23	6	21

For Water Quality +19

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	17	1	29
2	18	2	28
3	19	3	26
4	20	4	25
5	22	5	23
6	24	6	22

For Water Quality +20

# of Black Plants in Round	Outcome	# of Red Plants in Round	Outcome
1	18	1	30
2	19	2	29
3	20	3	27
4	21	4	26
5	23	5	24
6	25	6	23