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Beer-bottle tops: a simple forest management game

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SUMMARY

Forest planning and management concepts can sometimes be difficult to grasp. Games provide an effective way to demonstrate different concepts and facilitate deeper understanding of approaches and practices to sustainable forest management. In this paper we describe a game devised to demonstrate alternative ways to set allowable harvest levels in large (>10,000 ha) native forest planning units. The game requires minimal materials (photocopies of relevant maps and a few hundred beer bottle tops), and can be played and debriefed in 2-3 hours. The game focuses on the principles underlying area control and volume control of timber harvesting, and provides a basis for discussion of inventory and monitoring needs. The game has been popular and effective in courses for forestry professionals in developing countries, and for students in an undergraduate forestry course.

Keywords: sustained yield, forest management, area control, teaching and learning, simulation games

Capsules de bouteilles de bière: un jeu de gestion simple de forêt

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Un jeu avec des capsules de bouteilles de bière est un moyen efficace d'enseigner, et de renforcer les concepts de base qui soutiennent la gestion durable des forêts originelles. Le jeu requiert un minimum de préparation (photocopies des cartes et plusieurs centaines de capsules de bouteilles de bière), et peut se jouer et être résolu en 2-3 heures. Le jeu se concentre sur les principes à la base du contrôle du volume et de la surface de la récolte du bois, et conduit à une discussion sur les besoins d'inventaire et de gestion. Le jeu a été apprécié, et efficace, dans les stages professionnels pour les agents forestiers, ainsi qu'auprès des étudiants de licence en sylviculture.

Tapas de botellas de cerveza: un juego de gerencia simple de bosque

J. VANCLAY, R. KEENAN, A. GERRAND y I. FRAKES

Un juego basado en el uso de tapas de botellas de cerveza resulta ser un método eficaz para enseñar y reforzar los conceptos básicos que sustentan el manejo sostenible de bosques nativos. El juego requiere poco material (fotocopias de mapas relevantes y unos cientos de tapas de botellas de cerveza), y el juego y su análisis y retroalimentación se pueden realizar en dos o tres horas. El juego se centra en los principios que sostienen el control de área y volumen en la cosecha de madera, y conduce a una discusión sobre las necesidades en cuanto al inventario y monitoreo. El juego ha tenido mucho éxito y se ha mostrado eficaz en cursos de actualización para profesionales de manejo forestal y para los estudiantes de un curso universitario de silvicultura.

INTRODUCTION

Games are effective at imparting concepts in a memorable way and facilitating deeper understanding of principles and practices (Ryan 2000). For example, John Sterman's (1984, 1989) Beer game and Denis Meadow's (1992) FishBanks game have both been effective at communicating the need for feedback in business and in natural resource management systems, respectively. Sustainable forest management has some concepts that many students find difficult to grasp, but there are few games that allow demonstration of the concept of annual allowable cut in the management of native forests and the practical implications of approaches such as area control, volume control, and other alternatives. We created such a game during the development of training workshops to improve capacity for forest inventory and forest management in Papua New Guinea (PNG). We have found it to be effective and popular amongst foresters and students alike and hope that others will find it useful in improving understanding of forest management concepts and practices.

BASIC CONCEPTS

One of the goals of sustainable timber harvest management is to remove wood at a rate consistent with growth in a given forest area. The concept of setting an annual allowable cut for a forest estate is well established in forestry (e.g., Buongiorno and Gilless 2003, Vanclay 1996a), and was recorded as early as 1662 in Evelyn's *Silva*: "*… divide the Woods, and Forests, into eighty partitions; every year felling one of the divisions; so as no Wood is fell'd in less then fourscore years …*" (Evelyn 1662). Thus the annual allowable cut is the harvest that can be taken each and every year of an *n*-year cutting cycle, so that the resource is harvested in exactly *n* years. In theory, the rotation length or cutting cycle (80 years in Evelyn's case, and *n* years in general) should be chosen so that the growth in the forest is sufficient for another harvest, thus providing a non-declining harvest in perpetuity.

The basic concept is relatively simple, but the devil is in the detail and the estimation of an appropriate harvest remains challenging (e.g., Howard 2001, Preston and Vanclay 1988, Vanclay 1996b). Setting the rotation length (or cutting cycle in uneven-aged forests) requires knowledge of growth following harvesting and will often depend on other management objectives such as the need to maintain a particular stand structure for habitat or conservation. The simplest option is area control, in which an equal area is harvested each year. This is (at least in theory) easy to monitor, but in practice leads to a fluctuating harvest, because few divisions carry the same merchantable volume, or regrow at the same rate. Attempting to overcome this difficulty by creating divisions of unequal area (note that Evelyn did not state that the areas should be equal), simply creates a new difficulty of devising how to allocate the total area into *n* divisions of equal production potential, especially when the resource is not well known. Nor does it provide the flexibility that is sometimes needed for operational practice. For example, foresters may wish to vary the annual harvest to meet market demands or to take advantage of other situations (e.g., effective use of existing infrastructure, or salvaging wood after storms and other disasters).

A more flexible approach commonly adopted in modern polycyclic forest management systems is to relax Evelyn's requirement for specific divisions, and to control the volume harvested, allowing a given level of timber removal from specified locations in the estate in any one year. While this approach provides a better basis for industry development and flexibility in harvest distribution it does require careful estimation and monitoring of the volumes involved. If the initial estimates of the volumes per hectare or total standing volume are too high then the whole area will be cut over before the planned cycle time. If the estimated volumes are too low then the area will be utilized below its full potential.

While these considerations may seem self-evident to those with experience in timber harvest planning and management, we have found that they are often confusing to newcomers to the field. Various authors have offered analytical studies (Buongiorno and Gilless 2003), analogies (Vanclay 1996b), computer packages (Alder *et al*. 2002) and case studies (Vanclay 1994), all of which offer helpful insights, but none of which seem to convey the "eureka" moment that enables a reader to grasp a full understanding of the implications of alternative harvest management approaches. It was the frustration experienced in trying to convey a thorough understanding of the allowable cut concept that led us to develop the game described here. We have found that the 'beer-bottle top' game is helpful in allowing participants to experience first-hand the strength and limitations of each approach, and in initiating a discussion about how harvesting in native forests can be regulated most effectively.

The game as described here is designed to represent proposed management of a mature native forest estate that has not previously been subject to significant harvest and where there considerable variation in merchantable volume across the area and relatively little current growth in merchantable timber volume. This situation still applies in some tropical and temperate forest areas. Modifications are required to represent previously harvested native forest or a plantation estate where current growth needs to be taken into account in estimating future yields.

GAME MATERIALS

The game involves teams of people laying out tokens of different colours on a map, representing the distribution of forest with varying density of merchantable timber. Teams 'harvest' a number of tokens for a simulated year using strategies representing area control and volume control. We have found beer-bottle tops to be suitable tokens that are easily obtainable, and culturally appropriate for many forestry audiences, but seeds, pebbles or other tokens could be equally suitable. One useful attribute of 'crown-seal' bottle-tops (as used on beer bottles) is that they are distinctive when turned right-side up (because of different colours and brands), but look the same when upside-down. This characteristic adds realism to the game by creating a forest that appears homogeneous from above but has varying values according to the colour of the bottle top when turned over (harvested).

A large number of tokens is needed: ideally, a multiple of the rotation length, for each team (we do not advocate that participants or instructors acquire beer-bottle tops through personal consumption, and have found that local bar tenders are happy – if intrigued – to provide the necessary materials). In many of our games, preliminary discussions with participants have indicated that they were thinking of a 40-year rotation, so we have used 160 tokens per team, allowing an average of 4 tokens for each year of the 40-year cycle. This choice of round numbers simplifies the mathematics, allowing participants to focus on the principles rather than the mechanics of the game.

The tokens could be laid out on a board, but realism is added to the game if the tokens are placed on a map. One of our workshops focused on a proposed forest management area along the Ramu River (near Madang, on the north coast of the PNG mainland), with an area of about 160 000 hectares. This contributed to our decision to use 160 tokens. When placed on a 1:100 000 scale map, a beer-bottle top covers an area of about 700 ha. However, circular bottle tops do not pack tightly (like tiles on a floor), so when arranged on a map, the tops tend to occupy an area approaching 1000 ha. Thus 160 tops neatly covered our project area, covering part of a single 1:100 000 map sheet (Figure 1).

FIGURE 1 *Bottle tops placed upside down over the project area on a photocopy of a 1:100 000 map. (From left: Rod Keenan, Hartmut Holzknecht and Eileen Kolokol. Photo by Jerry Vanclay).*

We have found it advantageous to arrange for the 'beer-bottle top' game to be played in teams of about 4 players, to foster discussion within teams and competition between teams. Thus our equipment comprised one copy of the relevant 1:100 000 map sheet and 160 tokens (beer bottle tops) for each team. There is no necessity to use this scale or the 160 tokens, but using round numbers and an appropriate map scale helps to simplify calculations.

The tokens are intended to represent notional logging coupes, or 'set-ups' in our PNG example, each about 1000 ha in area. Individual logging units are rarely this large and participants need to understand that in reality this area will be distributed among a number of smaller units. In natural forest, such coupes generally differ greatly in volume (or value), according to the number, size and species of tree present. So it is with our beer-bottle tops. The bag of beer bottle tops that we obtained from helpful bar tenders usually contained 4 or 5 different kind of tops. Often about half were of one popular brand (in Madang, these were "Winim Ute", a promotion in which the prize was a car), and a small number were a deluxe variety (in Madang, about 2% were white "Export" brand). The labels and colours associated with these tokens was a matter of chance, according to the tops available at the local bar. The volumes that they represent were based on local experience: in Ramu, it was expected that much of the area harvested would yield around 10 m^3/ha, with smaller areas containing higher densities of merchantable timber. While the exact numbers attached to each kind of token is immaterial, it adds realism if appropriate values are used.

Because we wanted to foster competition and discussion, we prepared several identical sets of bottle tops, one for each team (this was the most time-consuming part of game preparation). The exact number of each kind of token varied on each occasion, but was typically 50% low value ('Winim', 10 m^3/ha), 30% medium ('SP', 20 m^3/ha), 18% high ('Ice', 30 m^3/ha), and 2% very high ('Export', 50 m^3/ha).

CONDUCT OF THE GAME

After an introduction to the game, participants are instructed to simulate one rotation of harvesting under area control, a second under volume control, and a third under volume control with feedback. In each case, the game is initialized by turning all the tokens upside down to hide their value, and by placing them on the map covering the harvestable area (Figure 1). Some participants may wish to arrange the tokens in a logical pattern (e.g., with high-volume tokens in valleys and low-volume tokens on ridges); this is not necessary, and will not affect the outcome of the game.

Area control: Participants are asked to harvest an equal area of the resource (take an equal number of tokens from the map) for each of the *n* time-steps representing an *n*-year cutting cycle. In our Madang workshop, participants each took 4 tokens, for each of the 40 time-steps representing the years of the cutting cycle (Figure 2). Participants should record the corresponding volume of wood that they harvested

FIGURE 2 *Participants simulating area control. Notice the selected tops in the background arranged in columns year by year, with four tops taken each year. (From left: Vitus Ambia and Sobbie Giok. Photo by Jerry Vanclay).*

in each step. In our Madang workshop, the volume harvested in any time step ranged from 40,000 (4 'Winim') to 160,000 m^3 (2 'Ice' plus 2 'Export'). We have found it useful to encourage participants to arrange the 'harvested' tokens as a bar chart (Figure 2). With area control, this arrangement will not vary in number of tokens (e.g., 4 per time step), but will vary in colour (and in the volume that they represent). Participants can also graph their annual harvest over time by hand or, if a computer is available, enter results into a spreadsheet.

It is not necessary to complete all the time steps of the cutting cycle; it may be desirable to interrupt the simulation before participants have completed the harvest, so that they do not have a complete census before attempting volume control (see below). When they have gained an understanding of the procedure and of the progress of the harvest, participants can be asked to address a few key questions:

- Did the harvest last for the full cutting cycle, or was it exhausted prematurely?
- Was the harvest an even-flow, amenable to a stable industry, or did it vary greatly from year to year?
- If the latter, is it desirable to try to smooth the fluctuations in volume harvested? If so, how?
- Some participants may have been seen to 'cheat' by trying to take note of the colours evident on the edges of the bottle tops: is this akin to reconnaissance inventory, and did it help contribute to better forest management?

After a discussion of these and any other issues that may arise, participants should progress to a simulation of volume control.

Volume control: With volume control, an initial estimate is made of the total standing volume, and harvesting attempts to harvest $1/n^{th}$ of this total each year of the n-year cutting cycle (given the assumption that the forest is a mature forest in a steady-state situation in which there is no net volume growth). This phase of the game commences with an inventory to assess the total standing volume, which is why it is important that participants have not computed the total volume during the area control exercise (This can be achieved by stopping the simulation before it reaches the final year, by collecting their worksheets, by swapping the bags of tokens if there are more than one group to give the impression that the totals may be different or by insisting that they base their estimates on their inventory estimate, irrespective of other knowledge they may have gained about the resource). As always, it is helpful to emulate local field procedures. In our first Madang workshop, participants were asked to carry out a 1% inventory, as required by PNG forest legislation, and to select two tokens on which to base their estimate (i.e., 2 tokens out of 160, slightly more than 1%). In other exercises, participants have protested that this sampling intensity is too low, and up to five tokens have been selected to sample the resource. Some participants adopt a random sample, some adopt a systematic sample, and some have adopted some form of stratified sampling, but because the tokens themselves are usually placed haphazardly, the sampling strategy rarely affects the outcome.

Having selected a sample of tokens, participants proceed to calculate the total standing volume and the allowable cut. In the first Madang workshop, these calculations were easy: the sample of 2 tokens was multiplied by 80,000 to estimate the total volume, and divided by the 40 year cutting cycle to estimate the allowable cut. Thus, for this fortuitous combination, the annual allowable cut could be calculated simply by doubling the value of the two-token sample, and adding three zeroes. In other circumstances, it is convenient to have a calculator handy for this step. Estimates of total standing volume in our example could therefore range from 1.6 to 8 million cubic metres (with the upper figure resulting if participants made the highly unlikely selection of two of the rare, highest value tokens in the sample) compared to the true figure of 2.81 million cubic metres. Corresponding allowable cut estimates would range from 40,000 to 200,000 m^3 per year for a 40 year cycle.

Once the allowable cut has been determined, participants proceed to simulate the chosen harvesting cycle, attempting to take this volume each year. Achieving the exact allowable cut is not always possible, as participants may unwittingly select a token with a higher unit value than required and surpass the required volume, or they may pause short of the target to avoid the risk of an overcut. This is a realistic outcome in practice and participants are told that once a token is selected, it must be removed ("You cannot stand the trees back up"), to prevent too much "fine-tuning" of their harvests. In this situation, participants need to decide an appropriate strategy to adopt when the desired allowable cut is not attained in any year (e.g., if the value of the tokens selected one year exceeds the allowable cut, should there be a carry-over to the next year?). We have found it helpful to leave this decision entirely to the participants, as it often leads to an instructive discussion. To add further realism, participants may also be urged to simulate their harvesting in a logical sequence across the landscape, mindful of the need to construct and maintain roads and other infrastructure. As in the previous phase, it is instructive for the participants to line up the harvested tokens as a bar graph, to illustrate the volumes and areas harvested each year (e.g., Figure 3) or graph the results by hand or computer.

When teams have exhausted the resource, or completed their simulation for a complete cutting cycle, it is time to revisit the questions from the previous step:

- Was the harvest volume an even-flow, and did it vary more or less than in the area control method or did it vary greatly from year to year?
- If the latter, what could be done to help smooth the fluctuations in volume harvested?
- How much did the harvested area vary from year to year, and can this be accommodated operationally?
- Did the harvest last for the full cutting cycle, or was it exhausted prematurely?
- If the latter, why? Was the inventory adequate? What could be done to make sure that the harvest can be

sustained for the full cutting cycle?

- Did any participants continue to 'cheat' by trying to take note of the colours evident on the edges of the bottle tops, and if so, did it help to attain a better outcome?

Workshop leaders may need to guide the discussion to ensure that participants realize that the harvest is very similar to the inventory, and that the running average of the harvested volume can offer a helpful supplement to the initial inventory, and can be used to update estimates of the remaining volume and the allowable cut necessary to eke out the resource to the end of the cutting cycle.

Volume control with feedback: The third and final phase is to repeat the previous step, but with periodic adjustments to the allowable cut based on monitoring of past harvests (Figure 3). Participants should themselves decide an appropriate interval for such adjustments. The process involves observing the areas and volumes harvested, and calculating the harvested volume per hectare during the monitoring period (say 5 or 10 years). This estimate can inform a revision of allowable cut, based on the residual standing volume divided by the remaining years in the cutting cycle. Participants may choose to review the volumes and areas at pre-defined intervals (e.g., when ¼, ½ and ¾ of the bottle tops have been selected), or whenever they begin to suspect an inadequate estimate. At each review participants should recalculate the estimated residual standing volume and compare it with the time to complete the cutting cycle and make adjustments to the target harvest to maintain the desired harvesting cycle.

FIGURE 3 *Participants near the end of a rotation simulating volume control with feedback, revising the allowable cut at mid-rotation. Note the tops already selected (harvested) laid out year by year, illustrating the different area harvested each year as each token represent approximately 1,000 ha. The map of the forest is obscured by the laptop computer. (From left: Eileen Kolokol and Barnabas Wilmot. Photo by Jerry Vanclay).*

This is the stage when most participants fully grasp the concepts of checking both the area and volume harvested during the rotation and begin to understand the importance of a periodic review and adjustment. By now, they should be able to work through the simulation quickly, should achieve a harvest that can be sustained until the end of the cutting cycle, and can anticipate the questions posed for discussion in this section can include:

- Did harvesting last for the full planned cycle in this case?
- How did the annual harvest vary over time? How was the pattern different to area control or simple volume control?
- What situations might continue to lead to overexploitation and early depletion of the resource or large changes in the allowable cut between monitoring cycles? What might the implications of this be for industry?

Other variations: The simulation can be enriched by a careful choice of maps, and of the volumes represented by bottle tops, to make the simulation realistic. It can be extended by spending some time at the outset defining the area of forest available for harvesting, with some tokens being removed to simulate the reduction in area available for harvesting associated with conservation or community reserves, stream buffers, steep slopes and other impediments to harvesting.

Alternative approaches can also canvas the issue of net versus gross area within a harvest unit. In practice in native forest, the planned harvest area is often not achieved because of local topographic restrictions, protection of special habitat areas identified at a local scale or other reasons. One way of demonstrating this is to make the tokens represent their actual area (in our case 700 ha), rather than the proportion of the land area they occupy on the map (1,000 ha). This difference will depend on the placement to tokens on the map (hexagonal or rectangular packing). Participants can discuss the magnitude of this type of reduction that should be accounted for and how it affects the allowable cut.

DEBRIEFING

The three phases of the 'bottle top' game lead very naturally to an insightful discussion about the merits of a smooth harvest (both in terms of timber harvested and area worked-over), of the need for reliable inventory, and of the need for on-going monitoring to compare inventory estimates and planned harvests with the actual outcome. If several teams are playing with identical sets of tokens, the discussion may also encompass sampling theory (e.g., the variance of inventory estimates).

Finally, there is an important question that should be put tactfully: Given what you have now learned about inventory and forest management, do you think that allowable cut estimates and operational procedures in your district are adequate? Often groups will say that they need more intensive inventory at the outset – or even a complete enumeration, which is usually impractical. One of the important points to draw out of discussions is that with periodic review and feedback, there is potential to learn from the operations as they progress and make adjustments to ensure the harvests can be maintained to the end of the rotation. Some groups do not realize that the data they are collecting in the actual harvests can be used in this way especially if this data is handled by separate parts of the organization (e.g., the sales, finance or marketing division rather than the inventory or planning part of the organization).

CONCLUSION

The 'beer-bottle top' game is easy to create with minimal materials, but is effective at communicating the concepts underpinning the notion of an allowable cut and at exposing the strengths and weaknesses of its several variants. We have used this game in diverse situations ranging from undergraduate to professional development situations. In all cases, evaluations indicated that participants enjoyed the experience, and gained new insights into the nature of sustained yield, the requirements for planning a sustained timber harvest and the implications for forest management.

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Forest planning game instructions

Requirements: for each team of 3-4 players

1. Matching or similar sets of 100-200 beer-bottle tops (or similar tokens) of 4-5 different colours, preferably the same colour underneath. Try to get many (about half) of one colour and fewer of the other colours. Assign a realistic timber volume to each type of token, for example, 10, 20, 30 and 50 m^3/ha, with higher values for the rarer types.

2. Map of the forest area. A 1:100,000 scale map means that each bottle top represents an area of about 1,000 ha. Ideally, this would have the area of forest available for harvesting marked on the map.

There are three stages to the game: *area control*, *volume control* and *volume control with feedback*.

Area control

Step 1

Distribute bottle tops over the forest area available for harvesting. Turn tops over (coloured side down), and arrange on the map so they cover the management area.

Step 2

Ask participants to estimate the cutting cycle (e.g., 40 years) required to provide sufficient volume growth for the subsequent harvest. Divide the net area by this cycle length to estimate the annual harvest area.

Step 3

Participants then simulate harvesting by taking this number of tops each year. Arrange the harvested tops in columns to form a bar chart of the area harvested, and record the area cut (constant) and volume harvested (computed from the value of the tops; fluctuating).

Step 4

Discuss the outcome. Can the harvest be maintained to the end of the cutting cycle? (in the absence of arithmetic errors, yes). How does the volume of the harvest vary?

Volume control

Step 5

Spread the tops out again (as in Step 1).

Step 6

Complete an 'inventory'. Decide on an appropriate sampling intensity (e.g., 2.5% or 4 out of 160), choose tops according to a sampling design of your choice (random; systematic; stratified), and estimate the total standing volume. Replace these tops before Step 7. Divide the estimated total standing volume by the cutting cycle (from Step 2) to arrive at an annual allowable cut.

Step 7

Simulate the harvest again, trying to achieve the target volume each year by varying the area harvested (i.e., the number of tops selected). Take tops in a realistic fashion (clustered together), bearing in mind that the need for road construction and practical issues may prevent patchwork harvests. Arrange the harvested tops in columns to form a bar chart of the area harvested, and record the area cut (fluctuating) and volume harvested (relatively constant).

Step 8

Observe and discuss the area cut and volume harvested each year, and whether the resource can be sustained to the end of the cutting cycle. How does this compare with area control? How good was your inventory? (Overestimates lead to a shortfall; underestimate leave some volume at the end of the cycle). What could be done to improve this system?

Volume control with feedback

By now, most participants will realize that the harvest is analogous with inventory, and that records from harvesting can be combined with prior inventory to make sure that the resource is managed to provide a harvest throughout the full cutting cycle.

Step 9

Spread the tops out again and take another inventory (as in steps 6 & 7).

Step 10

Simulate a harvest as in Step 7, but periodically (say every 5-10 years) review the volume and area harvested, and if necessary revise the annual allowable cut using new estimates of the remaining area and volume.

Step 11

Observe what happens to annual harvest after each review and in the long term.

Step 12

For the final wrap-up, compare the strengths and weaknesses of each approach. Encourage teams to compare findings, as each team will get a different result. Most participants can clearly see the benefits of:

- using volume control with feedback,
- having good inventory,
- getting (and using) reliable data on the harvest....