

## Deck Costruction Strategies for Magic: the Gathering

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Magic: the Gathering was conceived in the early ninetens by Richard Garfield and distributed in 1993 by the Wizards of the Cost company. Today nine editions of the card game, each with several related expansions, with more than 8000 different cards have been published, several millions people play this game world-wide, and tournaments are organized every year.

To play a game of Magic, a player needs a deck suitably ready for that matter. Beginners typically start out with only a starter deck, but over time by losing game over game, more cards are added to the player's stock through purchases or trading with other players. Therefore, any player end up with a, more or less, large stock of cards and the dilemma to choose how to build the best available deck.

The cards within a deck can be from a variety of different sets. There are different types of cards in the game: Creatures, Lands, Artifacts, Enchantments, Sorceries, and Instants. All cards in the game are referred to as "spells" for game purposes, except for land. Lands are not spells and are not "cast", but they are simply placed into play. With the exception of Lands, no more than four copies of any card can be used in a given deck. Creatures can be used either as attacking or defending tools.

The basic resource in Magic is called mana. Mana points are produced by Lands, Artifacts or by activated abilities of other spells. Mana let players bring certain cards into the game, and use abilities on cards already in play. The amount of mana needed in order to play a spell is its "spells casting cost". This information is located in the top right corner of any spell.

There are five different colors of mana in the game, each representing a separate force. The forces represented are typical of an adventure gaming genre: Black (B) mana is for the powers of death and evil; blue (U) mana is for the powers of the mind; Green (G) mana is for the powers of nature and wildlife; Red (R) mana is for the powers of destruction and chaos; White (W) mana represents the powers of good. Each colors theme is represented in the cards of that color (Creatures, Lands, and so forth). In addition, some cards do not have colors; these cards are either lands (which produce mana), or artifacts (which are colorless and can be played with any kind of mana).

In Magic each player starts with twenty life points, and when a player has his life points reduced to zero or has to draw a card, for whatever reason, and no cards are left from his deck, he loses the game. Within a game the players alternate in taking turns. Each turn is a sequence of events that involves drawing a card, putting cards into play, "attacking" the other player (using cards that represent creatures) and then discarding if necessary.

Magic, like many other games, combines the players abilities with an element of chance due to the random distribution of cards during shuffling, see Chen et al. [Chp. 14, 1] or <http://en.wikipedia.org/wiki/Shuffling.html>.

For more information on this game see [2] or the Magic page on Wikipedia at the URL: [http://en.wikipedia.org/wiki/Magic\\_\\_The\\_Gathering.html](http://en.wikipedia.org/wiki/Magic__The_Gathering.html).

The aim of this note is to introduce some mathematical ideas related to Magic. In particular we describe the mana bar graphs and a measure of a deck playability named mana number.

Mana graphs are a visual way to represent the mana needed to play a particular deck. In the case of a simple mono-color deck its graph is really simple to be drawn and to be understood. If we are playing a mono-color desk there is no point in using any different kind of lands, but the one with the same color of our spells. Henceforth, all mana, coloured or uncoloured, has to come from the same source. Then, it is enough to calculate the total mana cost of each spell, that means to add the colored mana cost and the uncoloured mana cost, and to plot the number of spells that have such a cost versus their mana cost. In this way we get several point in a plane that can be joined by straight-lines to get a graph. As an example consider the **Army of Justice** white mono-color starter deck, made with 40 cards, from the eighth edition. Here and in the

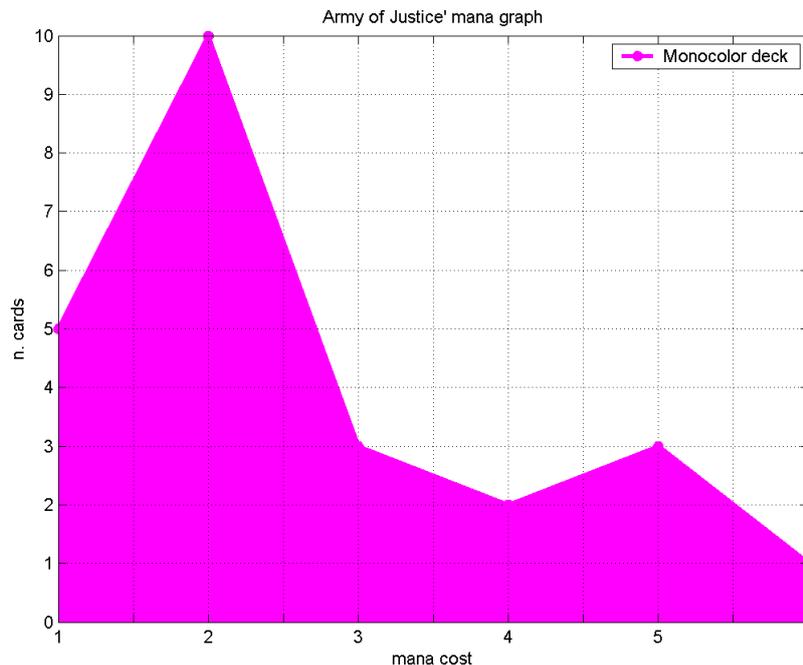


Figure 0.1: Mana graph of the **Army of Justice** mono-color deck.

following figures, we use the magenta color in order to represent the uncoloured mana cost. By looking at this simple graph one grasp how easy or difficulty is to play a deck. Several information are given by the above representation: it is possible to know how many spells require a given cost and it is a simple matter to judge if a particular deck has to be improved and how to improve it, for instance by reducing the spells that require a large mana cost or by adding stronger spells if they are missing.

However, these same information can be easily provided in simple words. This deck has 24 spells and 16 white (16W) lands. Within the spells we have that: 5 have a casting cost of 1 mana, 10 cost 2 mana, 3 are played with 3 mana, 2 for 4 mana, 3 with 5 mana, and 1 by 6 mana.

On the other hand, the simple deck representation introduced above does not provides any information on the mana available within a particular deck and, more important, it becomes inadequate as soon as we try to apply it to multi-colored decks. This last remark is confirmed by figure 0.2. From this figure we can notice that even if the top graph gives

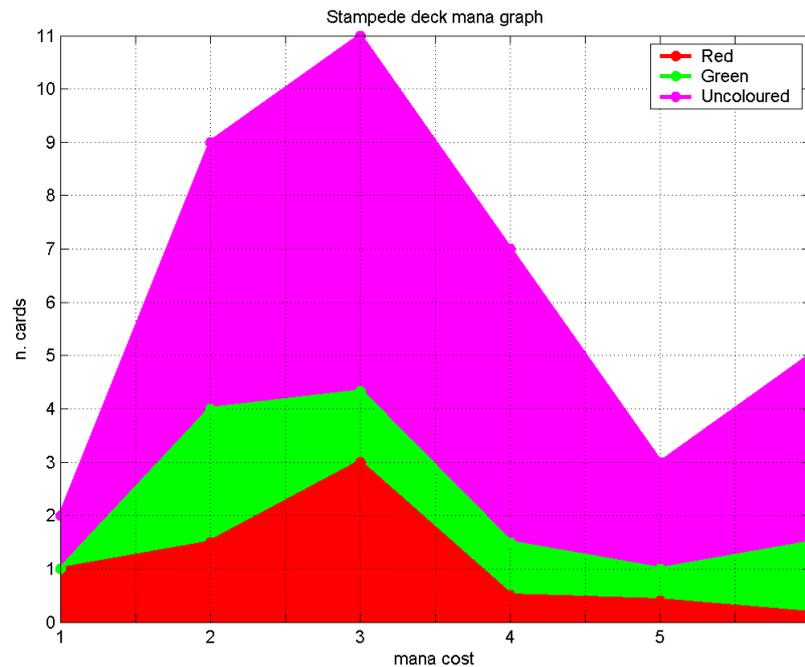


Figure 0.2: Combined graph curve of a bi-color deck. We use here the **Stampede** deck from the **Fifth Dawn** expansion.

us the information on the number of spells that require a total mana cost reported in the abscissa, we now miss the information concerning the particular spell cost of a given card.

Let us compare the above graph with a bar graph representation for the same deck. Here, and in the following bar graphs, we choose to report on the abscissa axes the single spells with increasing mana costs from left to right. Moreover, spells with the same converted uncoloured mana cost have always the same sequence of position: on the left if all the cost is uncoloured, from left to right according to increasing colored mana cost, and on the right if the colored mana cost is only one color. It is easily seen that this bar graphical report is by far more informative than the combined graph curve used before. In fact, we have here the full mana cost information related to the single spells. Moreover, we see at a glance the number of uncoloured spells and realize that, indeed, this deck is made by adding red spells to green spells, meaning that mixed spells are absent. Henceforth, the spells in this deck can be used to build decks of different colors without losing any of them. Finally, let us remark that the introduced bar graph

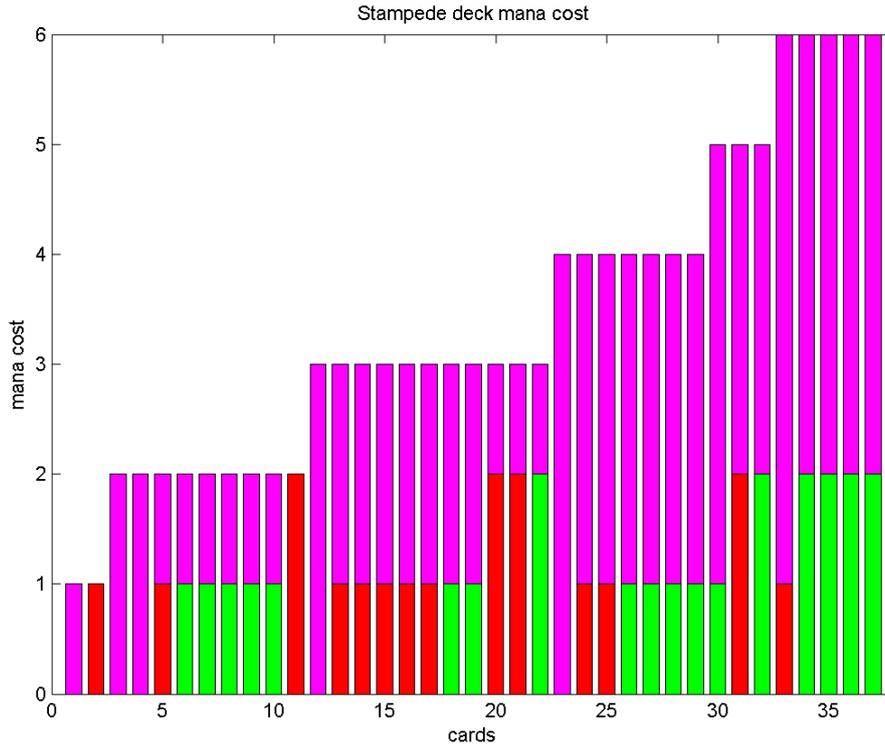


Figure 0.3: Bar graph of a bi-color deck. We use here the **Stampede** deck from the **Fifth Dawn** expansion.

representation can be easily generalized to the case of more than two colors decks. Of course, such a representation also lacks the information related to the mana availability.

In order to take into account the total mana available within a deck we can introduce a novel measure of a deck playable attitude that we call the *mana number* of a given deck. We introduce the following notation:  $I_k, B_k, U_k, G_k, R_k$  and  $W_k$  for the uncolour, Black, blue, Green, Red, and White mana cost, respectively. So that each spell within the desk can be cast by its equivalent uncoloured mana cost,  $C_k$ , given by

$$C_k = I_k + B_k + U_k + G_k + R_k + W_k .$$

However, for the definition of the mana number of a given desk we prefer to use a weighted cost indicator, that takes into account also the available number of lands of different colors, namely

$$C_k^* = \frac{I_k}{\ell_k} + \frac{B_k}{\ell_B} + \frac{U_k}{\ell_U} + \frac{G_k}{\ell_G} + \frac{R_k}{\ell_R} + \frac{W_k}{\ell_W} ,$$

where  $\ell_k, \ell_B, \ell_U, \ell_G, \ell_R$  and  $\ell_W$  are, respectively, the number of available Uncoloured, Black, blue, Green, Red, and White lands. Note that the available uncoloured lands  $\ell_k$  depends on the particular spell because different spells may have different colored mana costs, see below for some examples.

Let us consider first a creature with playing cost given by 3RGG, we have  $I_1 = 3$ ,  $R_1 = 1$ , and  $G_1 = 2$ , so that  $C_1 = 6$ . On the other hand, if we assume that the used deck

has 4 Uncoloured, 12 Red, plus 8 Green lands, that is  $\ell_1 = 4 + 11 + 6$  (this is because the uncoloured cost can be payed with all the available lands not already used to pay for the required colored mana),  $\ell_R = 12$  and  $\ell_G = 8$ , then we can compute the weighted cost

$$C_1^* = \frac{1}{7} + \frac{1}{12} + \frac{1}{4},$$

that is  $C_1^* = 10/21$ .

For comparison purposes, we consider now the same deck and two creatures in it with spelling cost given by 6RRRRRR, and 6GGGGGG, respectively. Hence  $I_2 = 6$ ,  $R_2 = 6$ , while  $I_3 = 6$ ,  $G_3 = 6$ , and  $C_2 = C_3 = 12$ . However,  $\ell_2 = \ell_3 = 18$  ( $\ell_2 = 4 + 6 + 8$  and  $\ell_3 = 4 + 12 + 2$ ), and we can compute

$$C_2^* = \frac{1}{3} + \frac{1}{2},$$

that is  $C_2^* = 5/6$ , but

$$C_3^* = \frac{1}{3} + \frac{3}{4},$$

that is  $C_3^* = 13/12$ , and therefore  $C_2^* < C_3^*$ , according to common feeling that the Red creature can be played more often than the Green one.

By considering a deck with  $N$  spells, the mana number  $M$  can be defined as

$$M = \frac{1}{N} \sum_{k=1}^N C_k^*,$$

where the  $C_k^*$  is the cost indicator associated to the  $k$ -th spell defined before. The higher is the mana number of a given deck, the more difficult is to play its spells. It turns out that the mana number of the **Stampede** deck is equal to 0.2035.

In the following table, we compare the mana numbers for the constructed decks sold by Wizard of the Coast for the 9th edition **Guildpact** and **Ravnica City of Guilds** expansions. Table 0.1 shows that the editor of Magic does not take into account the

deck name	colors	lands	$M$
<b>Code of the Orzhov</b>		10W+11B+3	0.1977
<b>Gruul Wilding</b>		11R+12G+1	0.2163
<b>Izzet Gizmometry</b>		10R+12U+3	0.1516
<b>Charge of Boros</b>		10R+10W+3	0.1846
<b>Dimir Intrigues</b>		11U+10B+3	0.2063
<b>Golgori Deathcreep</b>		11B+11G+2	0.1843
<b>Selesnya United</b>		10W+11G+3	0.2125

Table 0.1: Mana numbers for two colors decks of the **Guildpact** and **Ravnica City of Guilds** sets.

relative playability of different decks.

REFERENCES

1. K. Chen, P. Giblin and A. Irving, *Mathematical explorations with MATLAB*, Cambridge University Press, Cambridge, 1999.
2. *Wizards of the Coast, Magic: the Gathering Rulebook*, Wizards of the Coast, Inc., Renton, WA, 2005. Available from the URL: [www.magicthegathering.com](http://www.magicthegathering.com)