HearthNash - Generation and Analysis of Optimal Strategies for Hearthstone Match Formats

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Abstract

Hearthstone is a 1-vs-1 digital card game that is played competitively in a variety of formats. In a tournament, each player preconstructs several decks and then chooses at each point in the match what deck they will play, according to a chosen match format. Such tournaments measure players' skill and are exciting for viewers, but the match format can drastically affect the competitiveness and excitement. We developed HearthNash, software that can solve for optimal strategies and generate metrics to compare formats. We then used a large dataset collected from real Hearthstone players to generate metrics that reflect the competitive deck ecosystem, and used these results to draw conclusions about various match formats.

Results

By generating large sets of match trees with randomized deck inputs, our system is able to analyze certain quantities and compare them across different formats. The three metrics that we measured for each format are match length distribution (Figure 3), sensitivity to skill across *all* decks (Figure 4), and sensitivity to skill with a *single* deck (Figure 5).

We were able to run these analyses using matchup winrate data (Figure 7) from a real meta state in Hearthstone thanks to HSReplay (https://hsreplay.net/), a free deck tracker for players which doubles as a data aggregate and analysis service. HSReplay provided us with winrate data based on millions of games by high ranking Hearthstone players.

How does match format change expected match length?

Figure 3 - Match length distribution is quite consistent within each class of formats (best-of-1, best-of-3, and best-of-5).

Match Tree Generation

HearthNash is a match tree generation and analysis tool that takes in match format settings and deck matchup winrates, and generates a directed acyclic graph structure containing every possible sequence of decisions and outcomes for a given match. As the structure is created, it computes the expected match victory probability and optimal mixed strategy for each player. A small example tree is shown on the right (Figure 1).

Perform Your Own Experiments

We also developed a web interface (Figure 2) that allows you to generate and explore optimal match trees with HearthNash. Try it out at: dominic-calkosz.com/HearthNash/web-interface.html
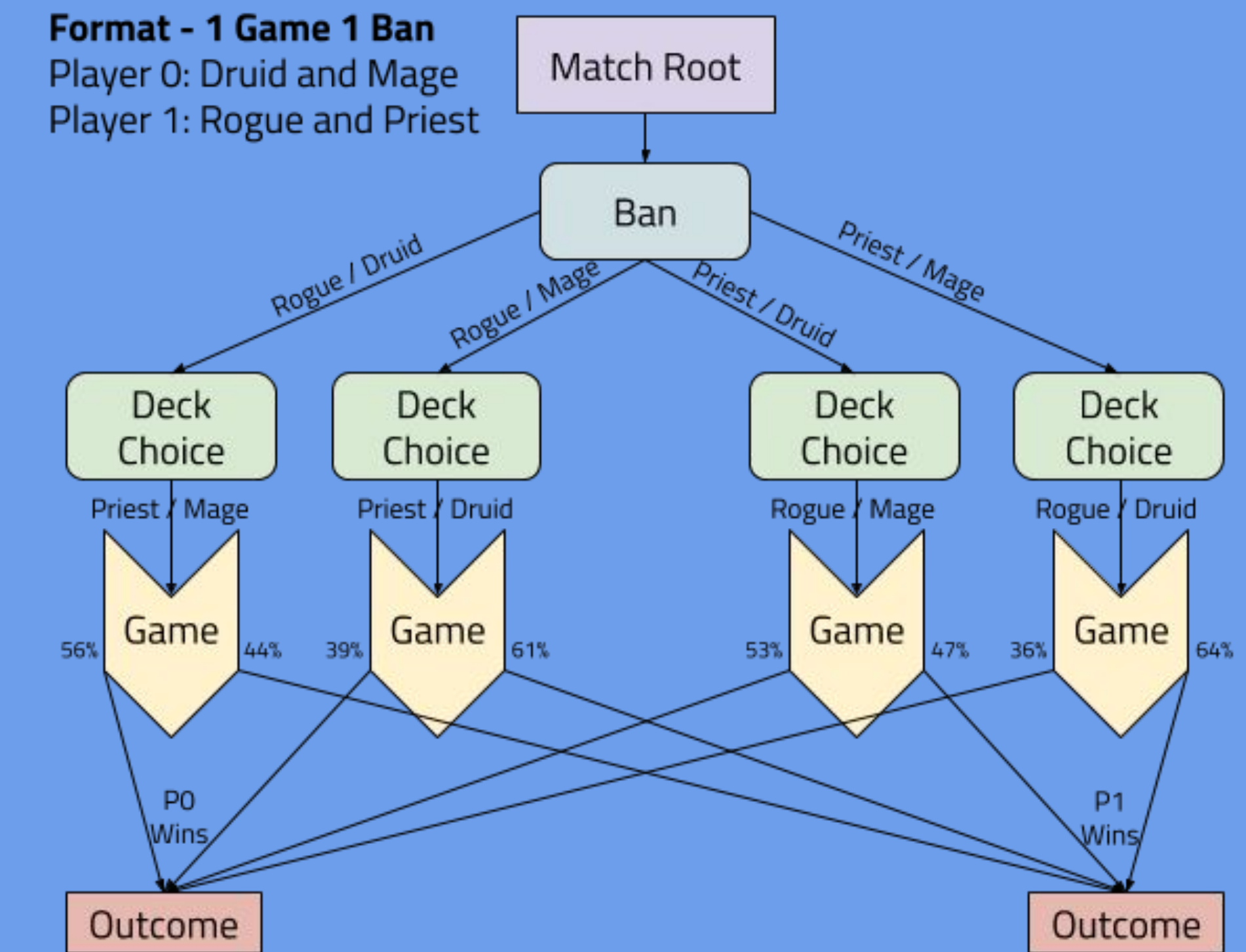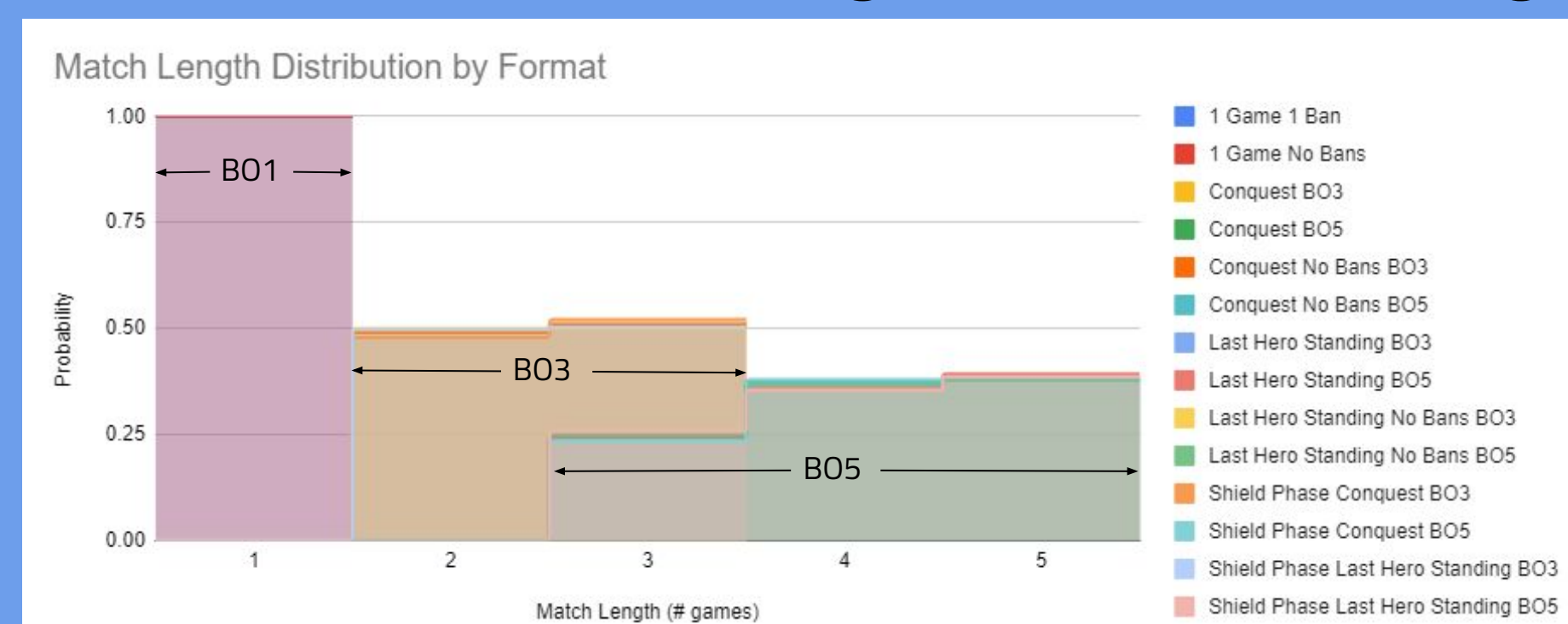

Figure 2 - Interactive Web Interface for Match Tree Generation and Exploration.

Figure 1 - Sample Match Tree

Future Work

There are several potential uses for HearthNash beyond what we have explored here. Additional metrics that could be analyzed include matchup variety and optimal deck practice strategies. HearthNash could also be extended to solve the deck selection phase prior to a given match.

There is potential for an empirical study on professional tournaments to determine if pro players tend to play optimally. One might also wonder what makes a format more exciting to viewers by studying Twitch or YouTube metrics.

Finally, the match structure that HearthNash uses may be applicable to more than just Hearthstone. Games such as Magic: The Gathering use similar match formats. HearthNash may also be applicable to drafting strategies in MOBAs and other games with similar pre-gameplay draft phases.

How does match format change sensitivity to player skill with all decks?
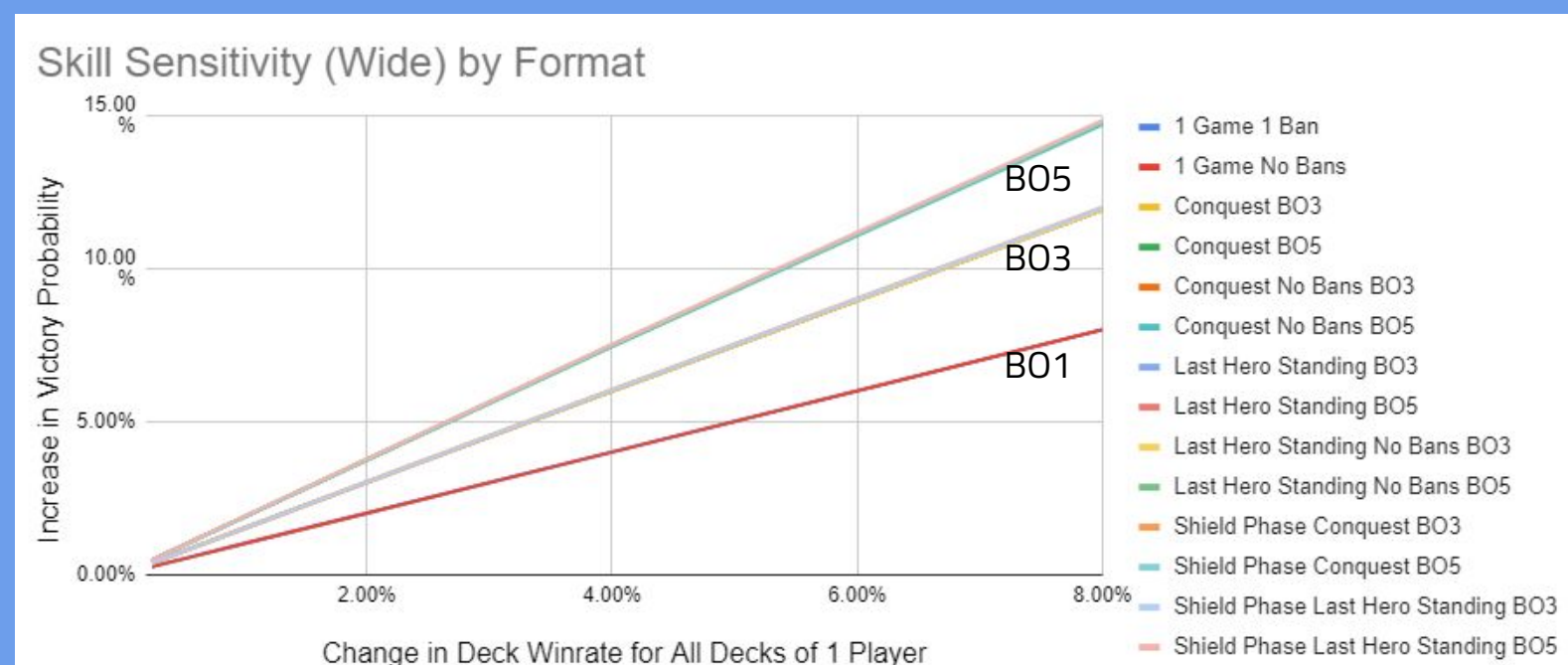

Figure 4 - Formats with more games show more sensitivity to *wide* skill improvements. Once controlled for number of games, little variation is seen between formats.

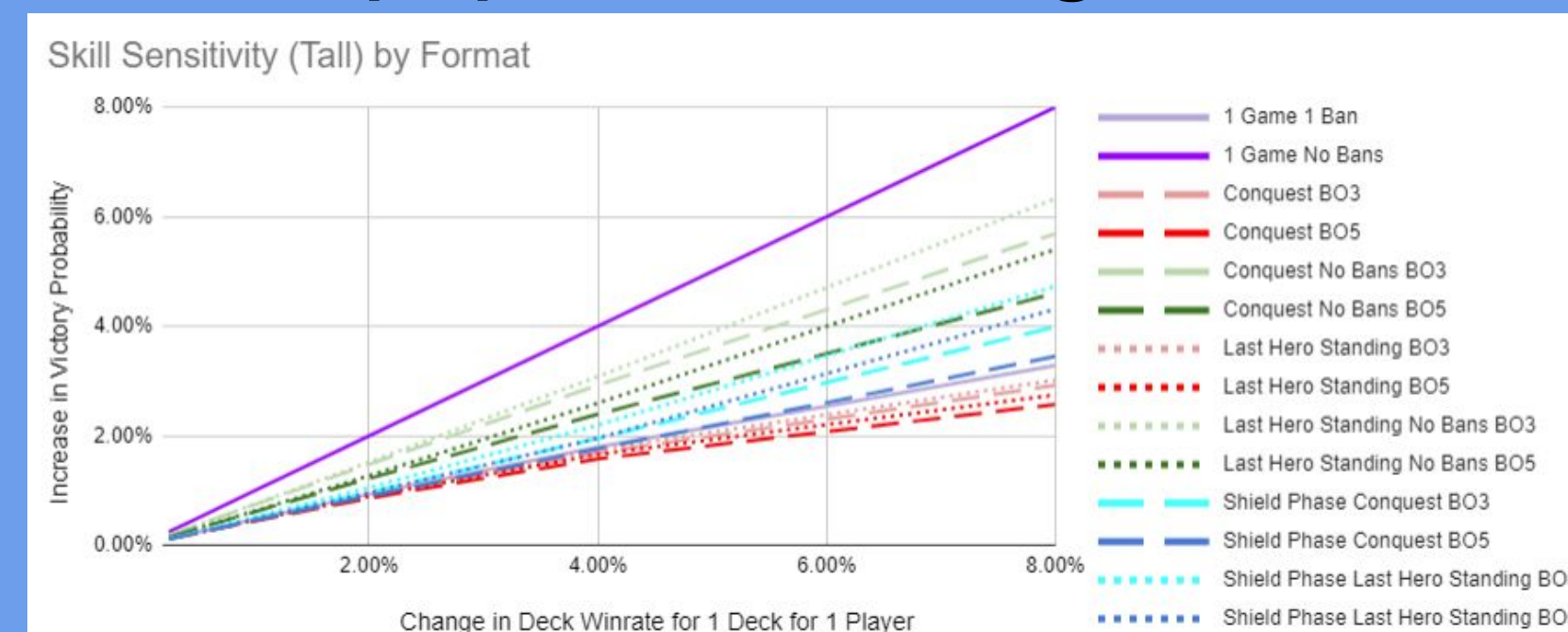### How does match format change sensitivity to player skill with a single deck?

Figure 5 - BO3 formats are more sensitive to tall skill improvements than BO5, contrary to wide. Last Hero Standing formats are all more sensitive to tall skill improvements than their Conquest counterparts.
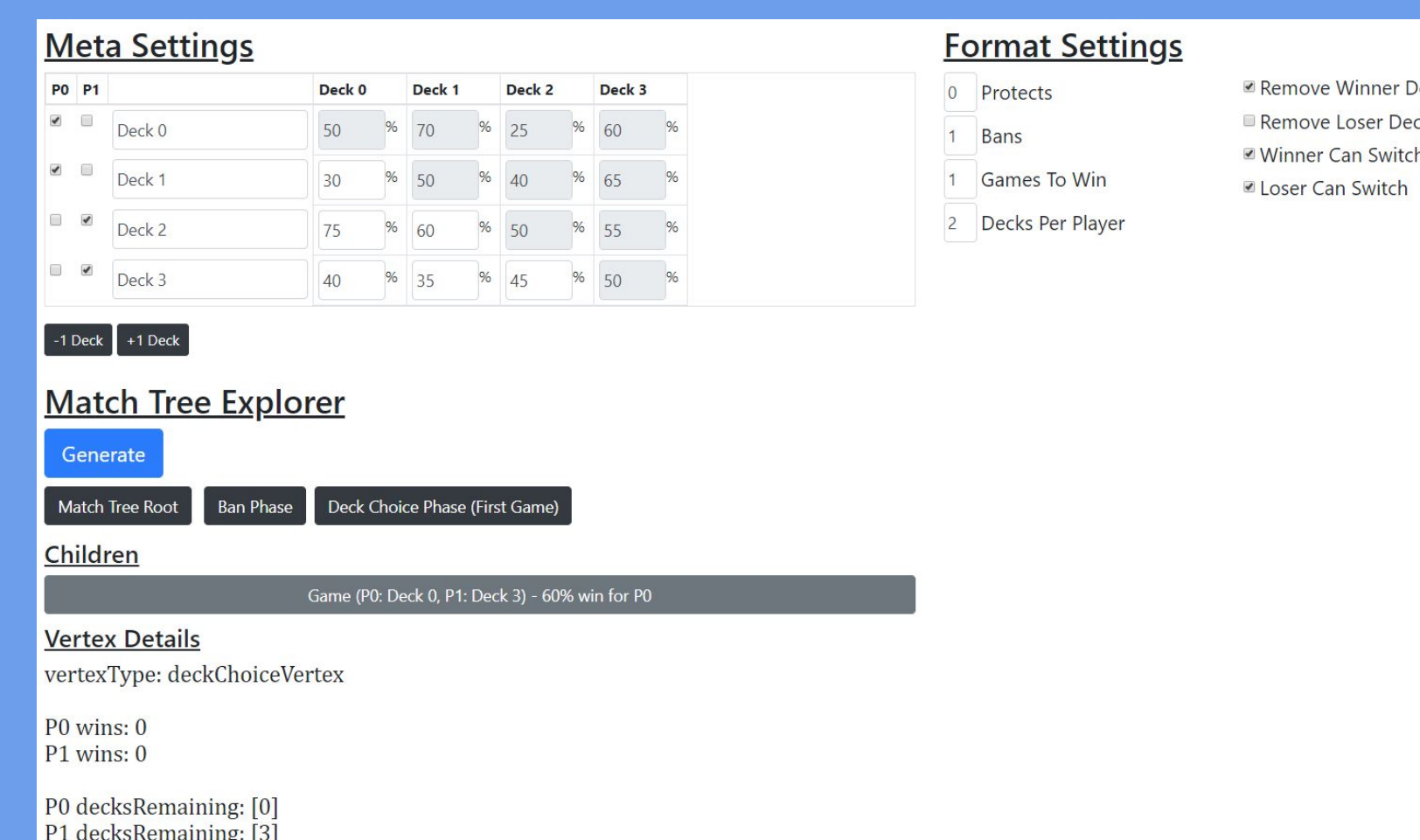
Format	Protects	Bans	Decks Removed	Can Switch Decks
Conquest	0	1	Winner	Both
Shield Phase Conquest	1	1	Winner	Both
Last Hero Standing (LHS)	0	1	Loser	Loser
Shield Phase LHS	1	1	Loser	Loser

Figure 6 - Defining properties of certain match formats.

Deck Archetype	Highlander Mage	Dragon Hunter	Mech Paladin	Resurrect Priest
Highlander Mage	50%	30.54%	48.57%	56.17%
Dragon Hunter	69.46%	50%	36.35%	46.52%
Mech Paladin	51.43%	63.65%	50%	41.87%
Resurrect Priest	43.83%	53.48%	58.13%	50%

Figure 7 - Archetype matchup winrates (subset of full dataset), courtesy of HSReplay.

Try out the HearthNash source code
https://github.com/Dmcdominic/HearthNash-Mirror