

# Reproducing Maine Ranked Choice Tabulations

Ken Lane

12/23/2019

## Contents

<b>1</b>	<b>2018 June Primaries</b>	<b>2</b>
1.1	Democratic Primary for Governor . . . . .	2
1.2	Maine CD2 Democratic Primary . . . . .	4
<b>2</b>	<b>2018 November General Election</b>	<b>6</b>
2.1	Second Congressional District . . . . .	6
<b>3</b>	<b>Session Information</b>	<b>6</b>

The case study follows from the author’s effort to independently and unofficially validate RC/IR tabulations presented by Secretary Dunlap for the three RC/IR contests<sup>1</sup>.

can be found [here](#).

In particular, the goal was to do the following:

1. Create a mathematical model of tabulation processing rendered in the vocabulary of set theory.
2. Examine State of Maine *RC/IR* election rules in the context of the model.
3. Develop and implement an algorithm to independently verify (potentially) tabulations produced by the proprietary algorithm currently deployed in State of Maine RC/IR elections.

Each of these efforts have proceeded in parallel, the first two partially documented herein.

To satisfy the third goal two artifacts have been created, each informing the development of the mathematical model:

- The R software package **rcvr** implements the mathematical model of Maine *RC/IR* tabulation.
- Powered by **rcvr** and *RMarkdown*, an interactive document has been written to support a rather thorough and reproducible examination of the tabulation process.

Three complementary models are considered in parallel: the **legal model** (rules), the **mathematical model** and the **implementation model** (**rcvr**). To that end, the mathematical and implementation models share terminology where practical, with consideration for vocabulary commonly used for elections.

Finally, only official and publicly available sources were used to identify *RC/IR* tabulation rules. To avoid adopting hidden assumptions, others with potential knowledge of rules or tabulation implementations were not consulted. A “clean room” strategy likewise affords an opportunity to evaluate the independence (clarity and concision) embodied by the rules. The assumption being:

---

<sup>1</sup>The footnote.

“Official rules ought to be sufficient to guide a software implementation of an **independent tabulator** capable of reproducing Maine RC/IR tabulations.”

```
library(plyr)
library(tidyverse)
library(kableExtra)
options(kableExtra.latex.load_packages = FALSE)
library(rcvr)
```

The R software package **rcvr** implements the mathematical model of Maine *RC/IR* tabulation. Routines can download and process data from the State of Maine website or from local files as appropriate. Thus far, three data sets are available, including:

- June 12, 2018 - Primary Election
  - Governor - Democrat (132250 CVRs)
  - Representative to Congress District 2 - Democrat (50845 CVRs)
- November 6, 2018 - General Election
  - Representative to Congress District 2 (296077 CVRs)

## 1 2018 June Primaries

### 1.1 Democratic Primary for Governor

Use `contest.R` to construct a `contest` instance for the gubernatorial primary. File locations and such are stored in `contest_keys.txt` and read by `contest.R` when `original == TRUE` using `contest_str` as a key.

```
gov_June <- rcvr::contest(
  contest_name = "Democratic Primary for Governor",
  original     = TRUE,
  contest_str  = "gov_June",
  creator      = "Ken Lane")
codes <- rcvr::get_codes(gov_June)
```

## Loading required namespace: plyr

Table 1: Metadata: Democratic Primary for Governor

Item	Value
Office	Governor
Jurisdiction	Maine
CVR location	<a href="https://www.maine.gov/sos/cec/elec/results/2018">https://www.maine.gov/sos/cec/elec/results/2018</a>
CVR file	govd-1.xlsx
CVR file	govd-2.xlsx
CVR file	govd-3.xlsx
CVR file	govd-4.xlsx
CVR file	govd-5.xlsx
Candidate	Cote, Adam Roland

Table 1: Metadata: Democratic Primary for Governor (*continued*)

Item	Value
Candidate	Dion, Donna J.
Candidate	Dion, Mark N.
Candidate	Eves, Mark W.
Candidate	Mills, Janet T.
Candidate	Russell, Diane Marie
Candidate	Sweet, Elizabeth A.
Candidate	Write-in
Number of Candidates	8
Number of Ranks	8
Number of Ballots	132250

June 2018 gubernatorial primary results posted by the State of Maine can be found [here](#). State of Maine can not be reproduced using the administrative rules described in [29-250 Code of Maine Rules Chapter 535: Rules Governing The Administration of Election Determined By Ranked-Choice Voting](#). The tabulation corresponding to the rules is easily generated.

```
tab1 <- rcvr::conduct_runoff(gov_June)
```

```
## Loading required namespace: plyr
```

```
df1 <- rcvr::make_report4(tab1)
```

Official Maine results can be duplicated by “tweaking” the rules.

```
tab2 <- rcvr::conduct_runoff(gov_June,
                             sequentialU = TRUE,
                             june2018    = TRUE)
df2 <- rcvr::make_report4(tab2)
```

Table 2: June 2018 Democratic Primary for Governor

	Round 1		Round 2		Round 3		Round 4	
	Rules	Reported	Rules	Reported	Rules	Reported	Rules	Reported
<b>Candidate Names</b>								
Cote, Adam Roland	35478	35478	37543	37543	42623	42623	53866	53866
Dion, Donna J.	1596	1596	0	0	0	0	0	0
Dion, Mark N.	5200	5200	0	0	0	0	0	0
Eves, Mark W.	17887	17887	19521	19521	0	0	0	0
Mills, Janet T.	41735	41735	44042	44042	49945	49945	63387	63384
Russell, Diane Marie	2728	2728	0	0	0	0	0	0
Sweet, Elizabeth A.	20767	20767	22987	22987	29944	29944	0	0
Write-in	748	748	0	0	0	0	0	0
<b>Ballot Exhausted</b>								

Table 2: June 2018 Democratic Primary for Governor (*continued*)

	Rules	Reported	Rules	Reported	Rules	Reported	Rules	Reported
By Overvotes	430	430	472	472	507	507	580	580
By Undervotes	5681	5681	7568	7568	9056	9056	14152	14155
By Exhausted Choices	0	0	117	117	175	175	265	265

```

r1 <- unlist(tab1$round4$result)
r2 <- unlist(tab2$round4$result)
diff <- (r1 != r2)
df <- gov_June %>% as.data.frame()
df <- mutate(df, code = codes)
dat <- df[diff, c(1, 2, 12)]
knitr::kable(dat,
  "latex",
  row.names = FALSE,
  booktabs = TRUE,
  caption = "Ballots of Interest",
  col.names = c("CVR ID", "Precinct", "Coded Choices"),
  digits = 2,
  longtable = TRUE) %>%
  kable_styling(latex_options = c("striped", "repeat_header"))

```

Table 3: Ballots of Interest

CVR ID	Precinct	Coded Choices
485831	Dixmont	GDUBUFEH
265479	Porter	BGDCUFUE
335281	Portland W2 P2	GUBFDUEA

## 1.2 Maine CD2 Democratic Primary

Use `contest.R` to construct a `contest` instance.

```

d2_June <- rcvr::contest(
  contest_name = "2018 Maine CD2 Democratic Primary",
  original     = TRUE,
  contest_str  = "d2_June",
  creator      = "Ken Lane",
  quietly      = TRUE)

```

Table 4: Metadata: CD2 Democratic Primary

Item	Value
Office	Congressional District 2
Jurisdiction	Maine
CVR location	<a href="https://www.maine.gov/sos/cec/elec/results/2018">https://www.maine.gov/sos/cec/elec/results/2018</a>
CVR file	congressd2-1.xlsx

Table 4: Metadata: CD2 Democratic Primary (*continued*)

Item	Value
CVR file	congressd2-2.xlsx
CVR file	congressd2-3.xlsx
CVR file	congressd2-4.xlsx
Candidate	Fulford, Jonathan S.
Candidate	Golden, Jared F.
Candidate	Olson, Craig R.
Candidate	St. Clair, Lucas R.
Number of Candidates	4
Number of Ranks	5
Number of Ballots	50845

Second district results can be reproduced using the administrative rules. Fewer ranks (5) avoid the rare pathologies found in the gubernatorial primary. In fact, the “tweaked” algorithm produces the same result as the official tabulation and the rules. First, using the administrative rules.

```
tab1 <- rcvr::conduct_runoff(d2_June)
df3 <- make_report2(tab1)
```

And now invoke the “tweaked” version.

```
tab2 <- rcvr::conduct_runoff(
  d2_June,
  sequentialU = TRUE,
  june2018    = TRUE)
df4 <- make_report2(tab2)
df  <- cbind(df3[,1:2], df4[,2], df3[,3], df4[,3])
```

Table 5: June 2018 Maine CD2 Democratic Primary

	Round 1		Round 2	
	Rules	Reported	Rules	Reported
<b>Candidate Names</b>				
Fulford, Jonathan S.	2489	2489	0	0
Golden, Jared F.	20987	20987	23611	23611
Olson, Craig R.	3993	3993	0	0
St. Clair, Lucas R.	17742	17742	19853	19853
<b>Ballot Exhausted</b>				
By Overvotes	108	108	134	134
By Undervotes	5526	5526	7217	7217
By Exhausted Choices	0	0	30	30

## 2 2018 November General Election

### 2.1 Second Congressional District

Use `contest.R` to construct a `contest` instance.

```
d2_Nov <- rcvr::contest(  
  contest_name = "November 2018 Maine CD2 General Election",  
  original     = TRUE,  
  contest_str  = "d2_Nov",  
  creator      = "Ken Lane",  
  quietly     = TRUE)
```

Table 6: Metadata: CD2 General Election

Item	Value
Office	Congressional District 2
Jurisdiction	Maine
CVR location	<a href="https://www.maine.gov/sos/cec/elec/results/2018">https://www.maine.gov/sos/cec/elec/results/2018</a>
CVR file	Nov18CVRExportFINAL1.xlsx
CVR file	Nov18CVRExportFINAL2.xlsx
CVR file	Nov18CVRExportFINAL3.xlsx
CVR file	AUXCVRProofedCVR95RepCD2.xlsx
CVR file	UOCAVA2CVRRepCD2.xlsx
CVR file	UOCAVA-AUX-CVRRepCD2.xlsx
CVR file	UOCAVA-FINALRepCD2.xlsx
CVR file	RepCD2-8final.xlsx
Candidate	Bond, Tiffany L.
Candidate	DEM Golden, Jared F.
Candidate	Hoar, William R.S.
Candidate	REP Poliquin, Bruce
Number of Candidates	4
Number of Ranks	5
Number of Ballots	296077

Tabulations using the administrative rules agree with official results [see here](#).

```
tab <- rcvr::conduct_runoff(d2_Nov)  
df  <- make_report2(tab)
```

## 3 Session Information

```
xfun::session_info(dependencies = FALSE)
```

```
## R version 3.6.2 (2019-12-12)  
## Platform: x86_64-w64-mingw32/x64 (64-bit)
```

Table 7: November 2018 Maine CD2 General Election

	Round 1	Round 2
<b>Candidate Names</b>		
Bond, Tiffany L.	16552	0
DEM Golden, Jared F.	132013	142440
Hoar, William R.S.	6875	0
REP Poliquin, Bruce	134184	138931
<b>Ballot Exhausted</b>		
By Overvotes	435	533
By Undervotes	6018	13838
By Exhausted Choices	0	335

```
## Running under: Windows 10 x64 (build 18362)
##
## Locale:
##   LC_COLLATE=English_United States.1252
##   LC_CTYPE=English_United States.1252
##   LC_MONETARY=English_United States.1252
##   LC_NUMERIC=C
##   LC_TIME=English_United States.1252
##
## Package version:
##   rcvr_0.1.0      kableExtra_1.1.0  forcats_0.4.0     stringr_1.4.0
##   dplyr_0.8.3     purrr_0.3.3       readr_1.3.1       tidyr_1.0.0
##   tibble_2.1.3    ggplot2_3.2.1     tidyverse_1.3.0   plyr_1.8.5
##   tidyselect_0.2.5 xfun_0.11         haven_2.2.0       lattice_0.20-38
##   colorspace_1.4-1 vctrs_0.2.1       generics_0.0.2    viridisLite_0.3.0
##   htmltools_0.4.0 yaml_2.2.0         rlang_0.4.2       pillar_1.4.3
##   withr_2.1.2     glue_1.3.1        DBI_1.1.0         dbplyr_1.4.2
##   modelr_0.1.5    readxl_1.3.1      lifecycle_0.1.0   munsell_0.5.0
##   gtable_0.3.0    cellranger_1.1.0  rvest_0.3.5       evaluate_0.14
##   knitr_1.26      fansi_0.4.1       broom_0.5.3       Rcpp_1.0.3
##   backports_1.1.5 scales_1.1.0       webshot_0.5.2     jsonlite_1.6
##   fs_1.3.1        hms_0.5.3         digest_0.6.23     stringi_1.4.5
##   grid_3.6.2     cli_2.0.1         tools_3.6.2       magrittr_1.5
##   lazyeval_0.2.2  crayon_1.3.4      pkgconfig_2.0.3   zeallot_0.1.0
##   xml2_1.2.2     reprex_0.3.0      lubridate_1.7.4   assertthat_0.2.1
##   rmarkdown_2.0  httr_1.4.1        rstudioapi_0.10   R6_2.4.1
##   nlme_3.1-143   compiler_3.6.2
```