North American Waterfowl Management Plan Science Support Team
Technical Report No. 2024-01

Guidance for Temporally Anchoring Regional Population Abundance Objectives to Migration Chronology for Calculation of Duck-Use-Days

Joseph D. Lancaster
Gulf Coast Joint Venture, Ducks Unlimited Inc.

Michael G. Brasher
Ducks Unlimited Inc.

Barry C. Wilson
Gulf Coast Joint Venture, U.S. Fish and Wildlife Service

ABSTRACT

Migratory Bird Habitat Joint Ventures (JVs) of the North American Waterfowl Management Plan (NAWMP) are tasked with quantifying regional waterfowl habitat objectives that support continental waterfowl populations at objectives outlined in the NAWMP. Fleming et al. (2019) developed a framework to derive non-breeding duck population objectives to inform JV habitat conservation planning in North America. The JV-level population objectives alone do not account for temporal variation in duck abundance and require additional migration chronology data to compute objectives across the non-breeding period. An important consideration to integrate population objectives and chronological abundance is selecting the appropriate "anchor point" date to which objectives are assigned. Fleming et al. (2019) suggested anchoring objectives at midpoints of the planning periods but acknowledged a need for more defensible guidance. The Gulf Coast Joint Venture Waterfowl Working Group recently developed a method to calculate species-specific anchor points applicable across Joint Ventures within autumn and winter periods. Our method calculates species-specific daily harvest distribution within each JV and identifies the individual date on which daily harvest distribution across JVs most closely matches the mean distribution of harvest across the entire period. As the latter was used by Fleming et al. (2019) as a proxy for abundance to proportionally allocate JV-level population objectives among JVs, this method offers an empirical approach to achieving coherence between independent planning parameters (i.e., population objectives and anchor points) in bioenergetic models. The result is a set of species-specific anchor points for the autumn and winter periods for potential use by all JVs. Application of anchor points and Fleming et al. (2019) step-down objectives across JVs allow calculation of JV-level population objectives across the non-breeding period that efficiently and consistently account for continental duck populations.

Recommended citation:
Lancaster, J.D., M.G. Brasher, and B.C. Wilson. 2024. Guidance for temporally anchoring regional population abundance objectives to migration chronology. North American Waterfowl Management Plan Science Support Team Technical Report 2024-01. 15pp.+ Appendix.

INTRODUCTION

Migratory Bird Habitat Joint Ventures (JVs) of the North American Waterfowl Management Plan (NAWMP) are tasked with quantifying regional habitat objectives to guide conservation delivery strategies for waterfowl and other birds. Consistency in the derivation of regional population abundance objectives across JVs is key to ensure efficient regional habitat delivery and avoid habitat shortfalls (Petrie et al. 2011, Fleming et al. 2019). Since the early 2000s, JV staff and partners have worked through the NAWMP Science Support Team (NSST) to develop consistent frameworks for stepping down NAWMP population objectives to regional scales, with much of the work focused on the non-breeding period. The 2018 NAWMP recognized the work of Koneff (2002), Petrie et al. (2011), and Fleming et al. (2017) as valuable advancements while noting remaining uncertainties.

Following guidance of the NAWMP, Fleming et al. (2019) developed a framework that provided a transparent method to allocate the long-term average and 80th percentile NAWMP objectives for 23 duck species, expanded to a continental scale, proportionally among JVs using contemporary (1999–2014) distributions of autumn (September–November) and winter (December–January) harvest in the U.S. and Canada and Mid-winter Waterfowl Survey estimates in Mexico. This method was endorsed by the NSST as an advancement over the Koneff (2002) method that used waterfowl distribution from the mid-winter waterfowl survey to step down continental population objectives to state scales and harvest information to allocate objectives to JVs within states. The Fleming et al. (2019) framework represents the most advanced opportunity for JVs to achieve consistency in establishing regional population and habitat objectives that collectively support continental duck populations.

Like previous step-down frameworks, the Fleming et al. (2019) framework established a population objective for a specific (albeit unidentified) point of time within the non-breeding period, which alone did not account for the temporal variation in duck abundance across the non-breeding period. Waterfowl are highly mobile and make abrupt movements within and across JV boundaries in response to environmental conditions, food availability, hunting seasons or other cues. Most non-breeding JVs assume the greatest population limiting factor during the non-breeding season is the availability of energetic resources to support target waterfowl populations. Habitat objectives required to provide these resources are estimated through development of bioenergetic models. Basic bioenergetic models account for the amount of dietary energy required by a target population of waterfowl through a planning period and are commonly expressed as waterfowl use days or duck energy days. Petrie et al. (2011) discussed two primary methods to derive duck energy day estimates: average residency time and migration chronology. Migration chronology represents the change in relative abundance of a species across time (e.g., non-breeding planning period) and is typically derived from surveys that capture the relative change in waterfowl abundance within the planning area at various temporal intervals. Survey information is typically averaged over multiple years to derive an average abundance across time intervals within the planning period. Examples of survey data used to derive migration chronology include semi-monthly or monthly aerial surveys, Integrated Waterbird Management and Monitoring (IWMM) surveys, or citizen science datasets (e.g., eBird).

Integration of the Fleming et al. (2019) autumn or winter population objective with a species' migration curve enables calculation of an area under the curve metric, which can be translated to the cumulative duck energy day demand across the planning period (Petrie et al. 2011). An important consideration in this process is selecting the appropriate anchor point, or the point in time at which the stepped-down continental population abundance objective is applied to the migration chronology curve (Figure 1). Depending on the shape of the migration chronology curve, selection of an anchor point date can have a significant influence on cumulative use-day estimates and thus habitat objectives. Anchoring the objective at a date with high relative abundance results in a lower cumulative use-day objective and vice-versa (Figure 2). However, the goal is neither to maximize nor minimize cumulative use-days but to anchor the objective such that the planning process provides an unbiased estimate of all individuals of a species using the JV on a given date of a representative year with continental waterfowl populations at NAWMP goal levels. Moreover, consistent application of the Fleming et al. (2019) stepped-down objective anchored to regional JV migration curves should ensure that the entire continental population abundance objective is accounted for within a JV region every day during the conservation planning period.

A consistent and objective approach for selecting an anchor point for use with the Fleming et al. (2019) framework has not been previously developed. An appropriate anchor point should at a minimum fall within the respective autumn or winter step-down period. Fleming et al. (2019) suggested the period midpoints (October 28 and January 1, respectively) as starting anchor points, but stated "we further identify an immediate need for consistent and more tangible guidance on selecting the date to which autumn and winter objectives are assigned and subsequently used to extrapolate over the entire planning period." The midpoint approach advocated by Fleming et al. (2019) assumes that the spatial distribution of ducks at the period midpoint is similar to the proportional distribution of harvest as measured across the entire autumn or winter period. In effect, this assumes most harvest, and thus the index of duck abundance across space, is centered around the mid-point. Fleming et al. (2019) acknowledged that the assumptions and ramifications of using the period midpoint deserved greater scrutiny and clear guidance on which dates to select as the temporal points of reference for population objectives.

The ramifications of selecting a biased anchor point are either a habitat shortfall or an estimated habitat need that exceeds energetics demand of continental waterfowl populations. If the Fleming et al. (2019) objective is anchored to migration curves too early in a period, when duck distribution is skewed toward northern latitudes, objectives would be anchored at low relative abundances on the migration curve at southern latitudes (Figure 3). This leads to exceptionally high objectives when the relative abundance of the species increases at southern latitudes later in the season and leads to inefficient habitat delivery (Figure 4). Moreover, the opposite effect occurs (i.e., inflated objectives at northern latitudes) if the anchor point is established too late within a period (Figure 5). An unbiased approach to identify the appropriate anchor point for Fleming et al. (2019) objectives result in the continental population objective being supported among JVs efficiently without substantial risk of habitat shortfalls or superfluous habitat delivery (Figure 6).

Another consideration in anchor point development is variation among species in their distribution and abundance through time. Migration strategies differ greatly among species, as some (e.g., blue-winged teal) depart northern regions early in the autumn period, while others (e.g., lesser scaup) depart much later and do not arrive at southern regions until mid- or late winter. These differences contribute to corresponding variation in the temporal distribution of harvest among species and regions. Therefore, the appropriate anchor point date will generally differ among species, and a desirable method for identifying anchor points should account for these differences.

During an update to its waterfowl population and habitat objectives, the Gulf Coast Joint Venture Waterfowl Working Group developed a method to derive species-specific anchor point dates for use with the Fleming et al. (2019) population abundance objectives and migration curves (Lancaster et al. 2021). The process derives empirically based and coherent anchor point objectives for all JVs and provides an additional layer of transparent and repeatable methods for ensuring consistency in supporting continental duck populations as they traverse JV boundaries during the non-breeding season. Specifically, the method calculates species-specific daily harvest distribution at the JV scale and identifies the individual date within the Fleming et al. (2019) autumn and winter periods on which daily harvest distribution across JVs most closely matches the distribution of harvest across the entire period (Figure 3).

METHODS

Assuming the distribution of harvest is a reasonable representation of the relative abundance of waterfowl among JVs during autumn and winter, an objective anchor point can be calculated by determining the date within the Fleming et al (2019) period when harvest distribution across JVs approximates the distribution of proportional harvest of that species across the seasonal period (Fleming et al. 2019). This value can be mathematically determined by finding the calendar date within the autumn or winter period where the sum of squares difference between the proportion of a species harvested in each JV and the proportional allocation of the species to that JV across the entire autumn−winter period is minimized (Figure 7) using the equation:

$$SumSquares_{ki} = \sum_{j=1}^{J}\left(\left(\frac{Harvest_{jki}}{\sum_{j=1}^{19} Harvest_{jki}}\right) - PFlem_{jk}\right)^{2} \qquad \text{(Eq. 1)}$$

where *j* represents a Joint Venture, *k* is duck species, *i* is calendar date within the autumn or winter period, and PFlem is the proportional distribution of 1999−2013/14 harvest across the period of interest from Fleming et al. (2019). Applying the equation results in a species-specific sum of squares value for each calendar date within the seasonal period (Figure 7). The calendar date with the lowest sum of squares value is when the spatial distribution of a species (as represented by harvest) most closely mirrors the spatial distribution of harvest across the entire seasonal period, and, thus, is identified as the most coherent anchor point for Fleming et al. (2019) population objectives. Anchoring the period-specific population objective on a migration chronology curve at this date produces an efficient allocation of objectives across JVs. This method can alternatively be visualized as finding the date when the relationship between the proportional distribution of mallard harvest across JVs in the winter period versus the proportional distribution of harvest across the entire period across JVs most closely matches a 1:1 relationship (Figure 8). We used Equation 1 with Canadian and U.S. duck harvest estimates from 1999−2013/14 to calculate species-specific anchor points for the autumn and winter periods for all JVs.

RESULTS

We applied the sum of squares equation to all 23 duck species included in the Fleming et al. (2019) step-down framework during the autumn and winter periods. Anchor point dates varied by species and ranged from 4 September to 16 November in autumn and 13 December to 23 January in winter (Table 1). Species-specific sum of squares graphs are provided in Appendix 1. Commonly harvested species that are ubiquitous across JVs (e.g., mallard, gadwall) had anchor points that were near the period midpoints, whereas other species were typically skewed from the midpoint consistent with migration patterns.

DISCUSSION

Selection of the appropriate anchor point in conservation planning for non-breeding waterfowl ensures sufficient waterfowl habitat is available without risking substantial shortfalls or costly excessive habitat delivery. Uniformity among regional JVs in conservation planning ensures that continental populations are supported regardless of their migration patterns among JVs during the non-breeding period. We developed an objective and repeatable process to identify empirically based species-specific anchor point dates for 23 duck species to be used in conjunction with the Fleming et al. (2019) step-down framework. We presented the methodology to a subset of Fleming et al. (2019) authors and received feedback that the method was philosophically consistent with their work, reasonable to identify coherent anchor points, and was an advancement over prior methods.

For some species, there are numerous calendar dates where sum of squares value is small and very similar to the minimum value, especially during the winter period. While selection of any of these minimum values would be defensible anchor points, selecting the absolute minimum provides a transparent and repeatable process that removes any potential bias in the process. Like

Fleming et al. (2019), this method assumes that harvest distribution is representative of a species' relative abundance across the landscape during the autumn and winter periods. This assumption was identified by Fleming et al. (2019) as needing further evaluation, and that guidance also applies to our methodology.

The pending update of the NAWMP will likely advocate for the JV community to embrace Fleming et al. (2019) as the preferred approach for stepping down continental duck population objectives. We further advocate for additional uniformity in application of Fleming et al. (2019) population objectives to species-specific migration chronology curves using the anchor points in Table 1. Additional uncertainties and assumptions outlined by Fleming et al. (2019) remain and should be considered as time and resources allow. Choice and availability of data for development of migration chronology remains a source of discrepancy among JVs. Ongoing work to develop migration chronology through the integration of citizen science data (i.e., eBird) and other waterfowl survey information will advance guidance for development of species-specific migration chronology that would further unify the step-down process among JVs and increase the efficiency in conservation planning for North American waterfowl.

REFERENCES

Fink, D., T. Auer, A. Johnston, V. Ruiz-Gutierrez, W.M. Hochachka, and S. Kelling. 2020. Modeling avian full annual cycle distribution and population trends with citizen science data. Ecological Applications 30:e02056.

Fleming, K. K., M. G. Brasher, D. D. Humburg, M. J. Petrie, and G. J. Soulliere. 2017. Derivation of regional, non-breeding duck population abundance objectives to inform conservation planning. North American Waterfowl Management Plan Science Support Team Technical Report 2017-01. 32pp.

Fleming, K. K., M. K. Mitchell, M. G. Brasher, J. M. Coluccy, J. D. James, M. J. Petrie, D. D. Humburg, and G. J. Soulliere. 2019. Derivation of regional, non-breeding duck population abundance objectives to inform conservation planning — 2019 Revision. North American Waterfowl Management Plan Science Support Team Technical Report 2019–01. 44pp.

Koneff, MD. 2002. Derivation of regional waterfowl population objectives from NAWMP continental population objectives. U.S. Fish and Wildlife Service. Unpublished Report.

Lancaster, J. D., B.C. Wilson, and the Gulf Coast Joint Venture Waterfowl Working Group. 2021. Gulf Coast Joint Venture wintering waterfowl population and habitat objective model refinement 2021. Gulf Coast Joint Venture, Lafayette, Louisiana, USA. 75pp., + Appendices

Petrie, M.J., M.G. Brasher, G.J. Soulliere, J.M. Tirpak, D.B. Pool, and R.R. Reker. 2011. Guidelines for establishing Joint Venture waterfowl population abundance objectives. North American Waterfowl Management Plan Science Support Team Technical Report 2011-1. 36pp.

Table 1. Species-specific anchor point dates for the autumn and winter period for use with the Fleming et al. (2019) step-down process.

Species		Anchor Point Date: Autumn	Anchor Point Date: Winter
ABDU	American Black Duck	20 October	31 December
AGWT	American Green-winged Teal	16 October	1 January
AMWI	American Wigeon	13 October	19 December
BAGO	Barrow's Goldeneye	15 November	15 January
BUFF	Bufflehead	16 November	15 December
BWTE	Blue-winged Teal	4 September	2 January
CITE	Cinnamon Teal	6 October	23 January
CANV	Canvasback	20 October	9 January
COGO	Common Goldeneye	2 November	13 December
EIDR	Eider (Common and King)	23 October	29 December
GADW	Gadwall	24 October	29 December
HOME	Hooded Merganser	10 October	28 December
LTDU	Long-tailed Duck	6 November	13 December
MALL	Mallard	29 October	31 December
MERG	Merganser (Common and Red-breasted)	13 November	17 December
NOPI	Northern Pintail	19 October	5 January
NSHO	Northern Shoveler	19 October	19 December
REDH	Redhead	18 October	1 January
RNDU	Ring-necked Duck	6 October	5 January
RUDU	Ruddy Duck	28 October	18 December
SCAU	Scaup (Lesser and Greater)	13 October	5 January
SCOT	Scoter (Surf, White-winged, and Black)	14 October	29 December
WODU	Wood Duck	6 October	13 January

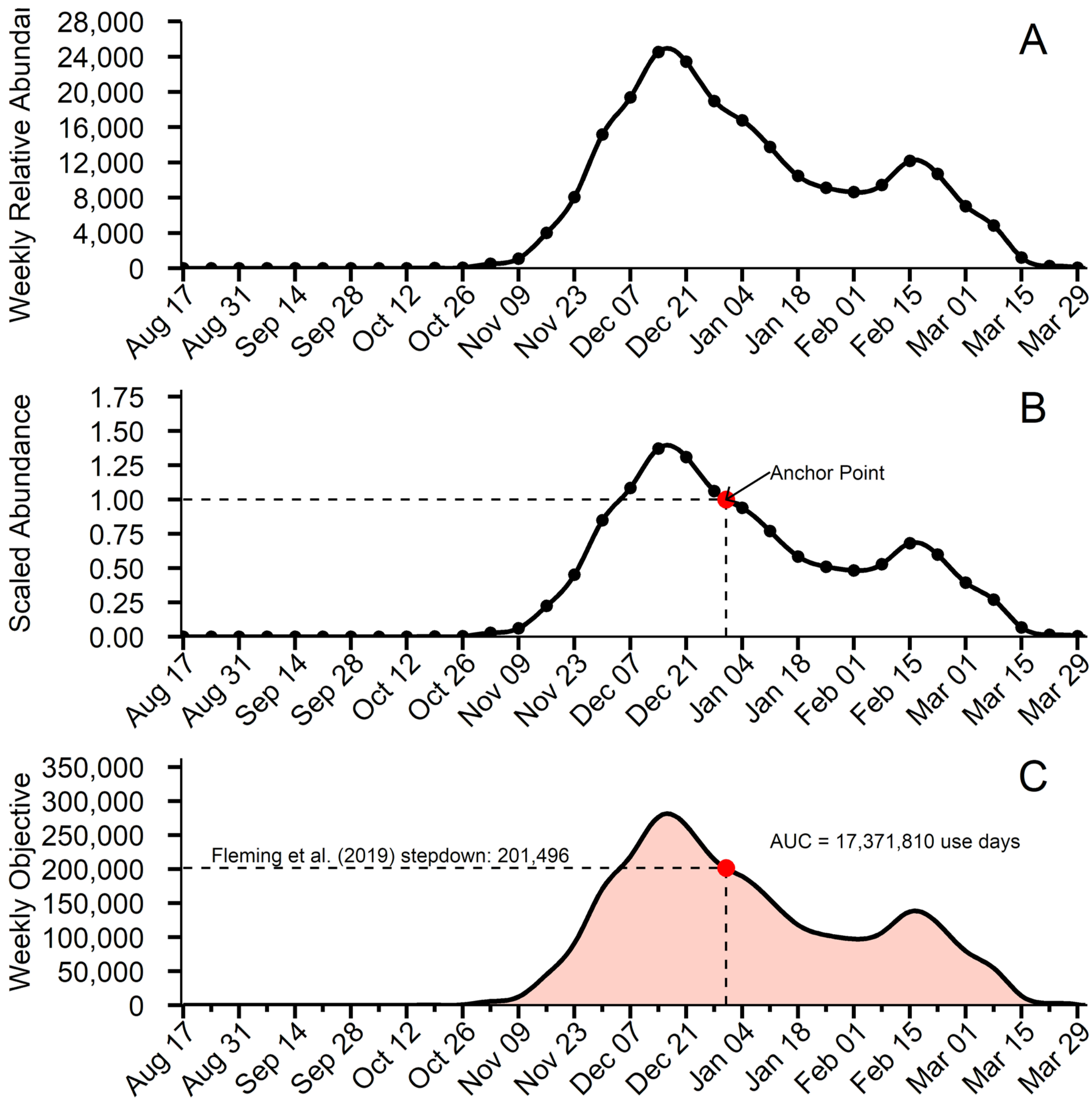


Figure 1. Basic application of an anchor point to migration chronology curve to translate stepped-down objectives to duck energy day estimates across the planning period: A) migration chronology of mallards in southwestern Louisiana derived from eBird Status and Trends data (Fink et al. 2020), B) selection of an anchor point associated with a particular date within the winter period and re-scaling the y-axis, and C) multiplying the Fleming et al. (2019) step-down objective by weekly relative abundance to derive weekly use day estimates. Cumulative use day estimates across the entire 228 day period total over 17 million.

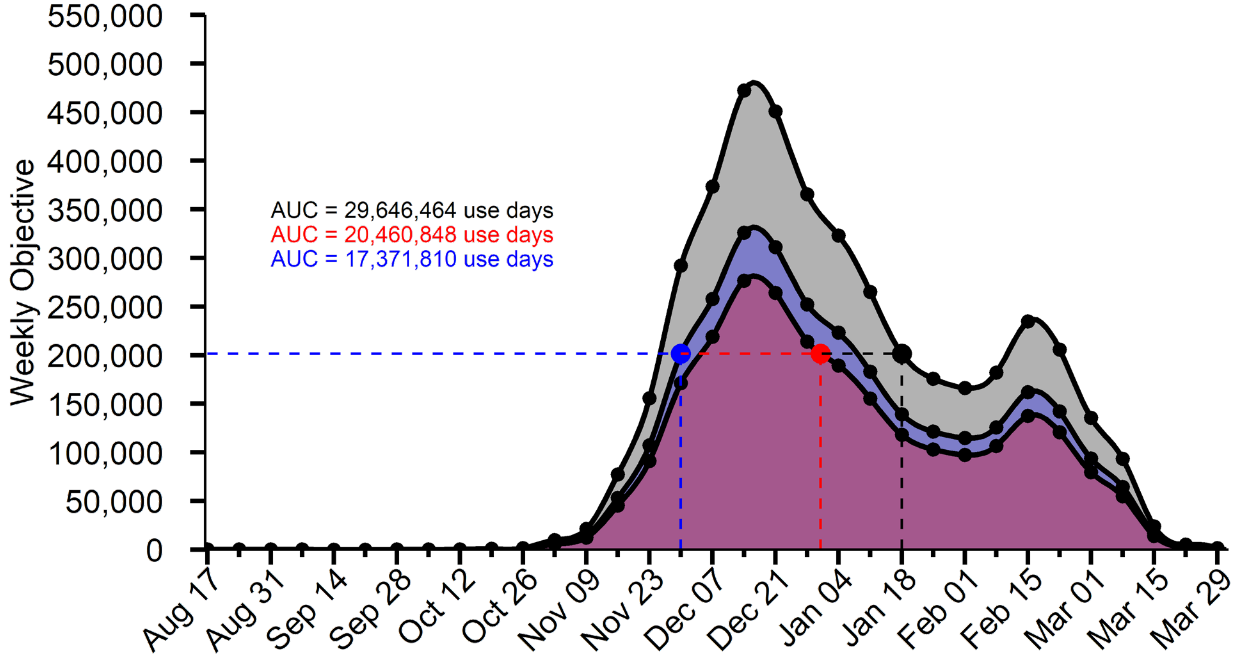


Figure 2. Effect of selecting different anchor point dates (blue = November 30, red = December 31, and black = January 18) on area under the curve (AUC) estimates, which translate to duck use days for a given species. Data for mallards in southwestern Louisiana.

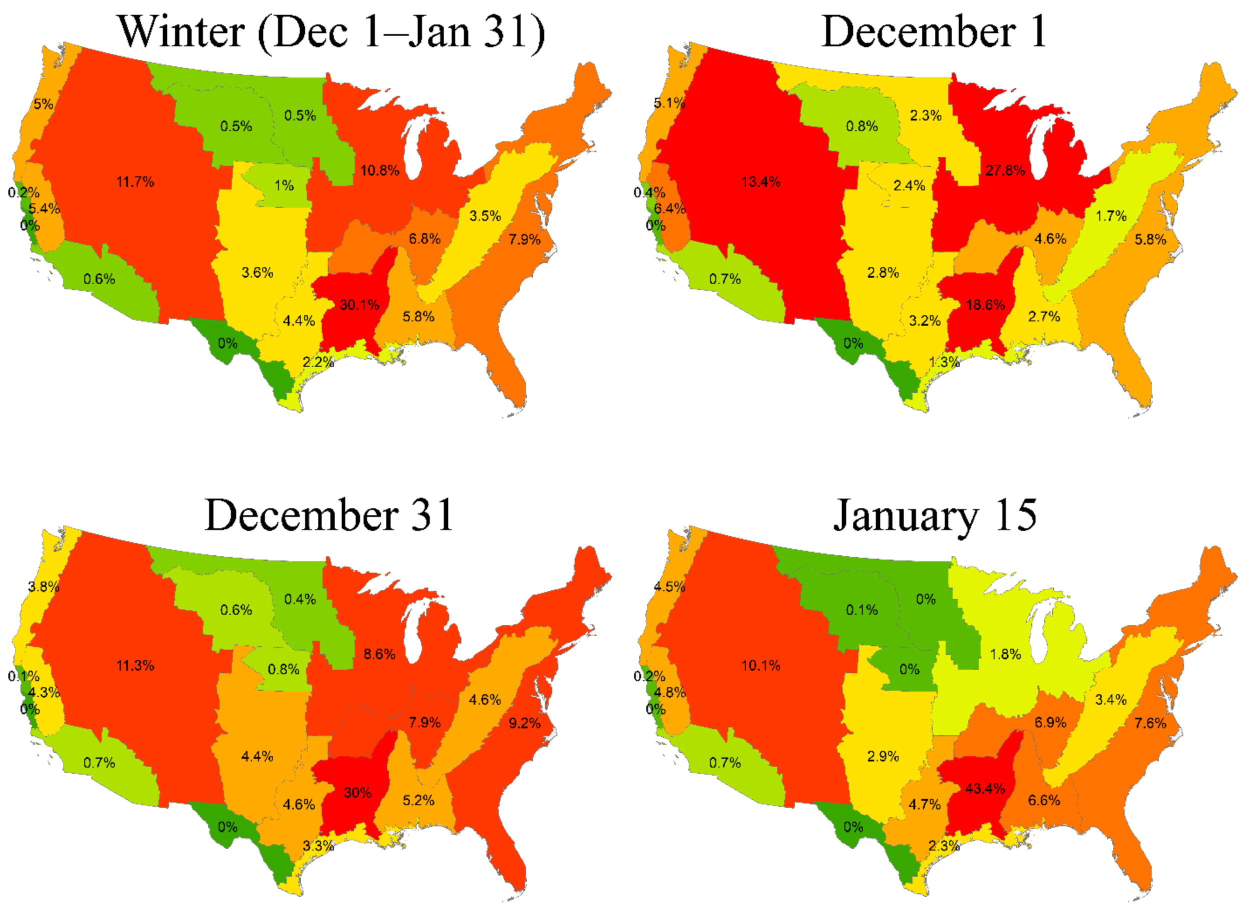


Figure 3. Proportional distribution of mallard harvest on December 1 (top right), December 31 (bottom left), and January 15 (bottom right) compared to the proportional distribution of harvest across the entire winter period (top left; December 1–January 31).

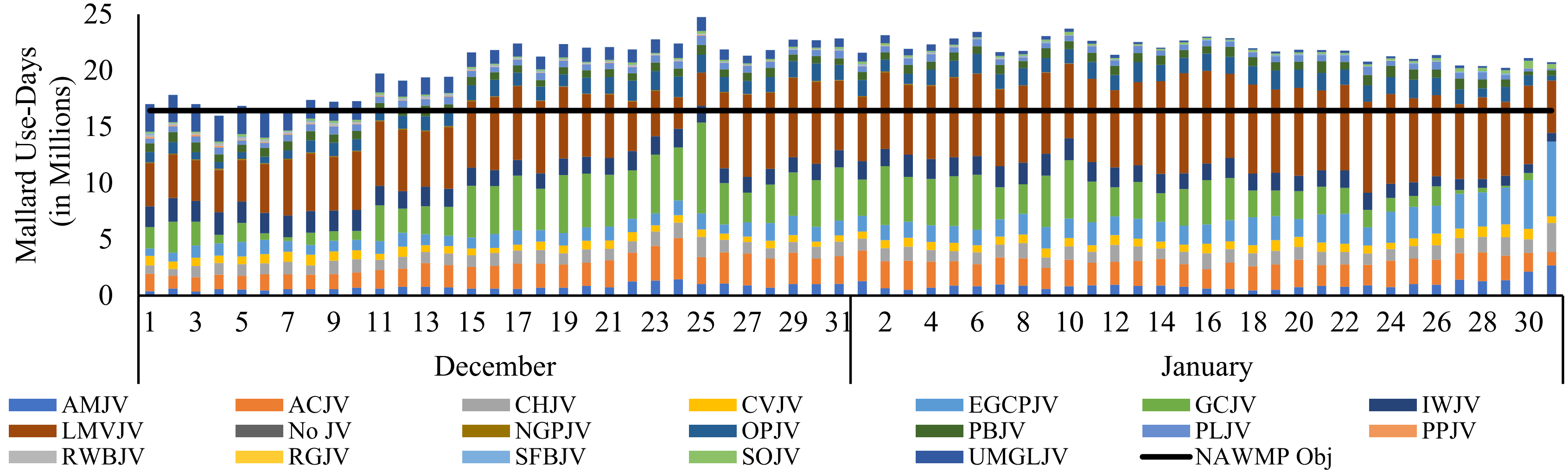


Figure 4. Overestimation of daily objectives at southern latitude JVs as a result of anchoring too early in the period when species distribution is skewed toward northern JVs. Fleming et al. (2019) continental winter mallard objective shown by black line.

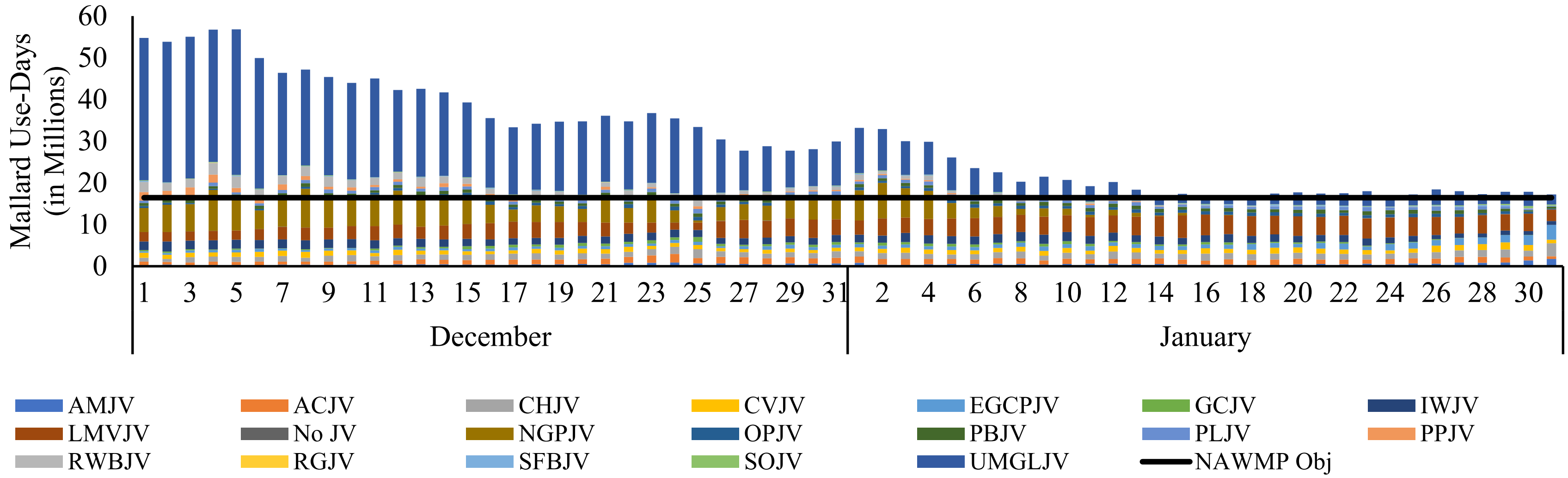


Figure 5. Overestimation of daily objectives at northern latitude JVs as a result of anchoring too late in the period when species distribution is skewed toward southern JVs. Fleming et al. (2019) continental winter mallard objective shown by black line.

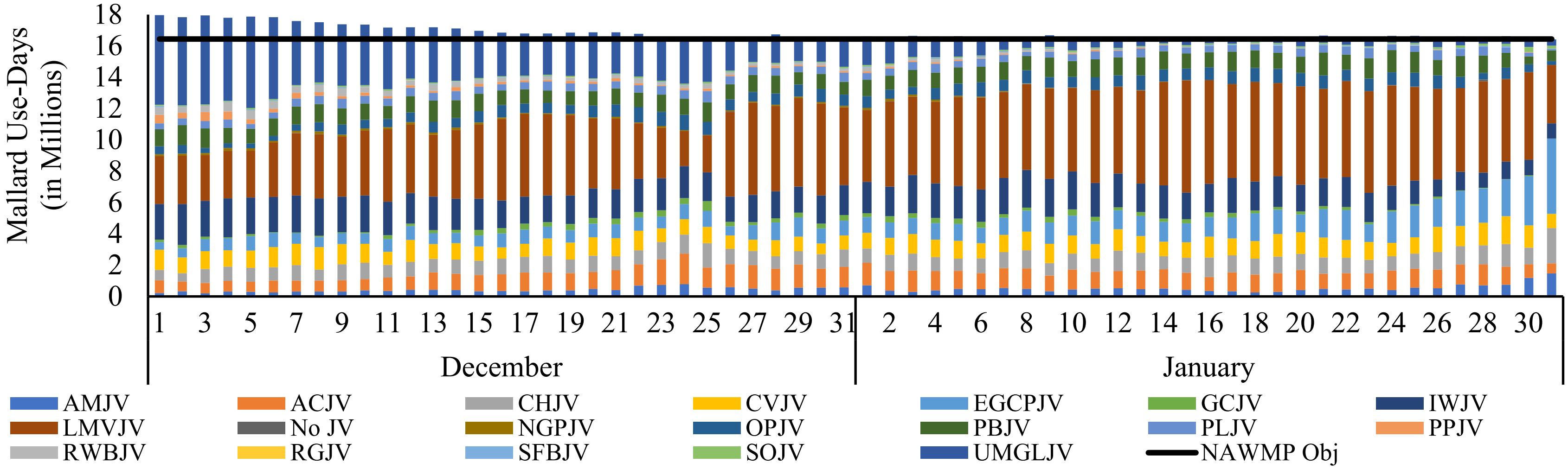


Figure 6. Anchoring on a date when a species is distributed across the landscape in similar proportion to the entire period leads to efficient and coherent apportionment of the NAWMP population abundance objective across the entire planning period. Fleming et al. (2019) continental winter mallard objective shown by black line.

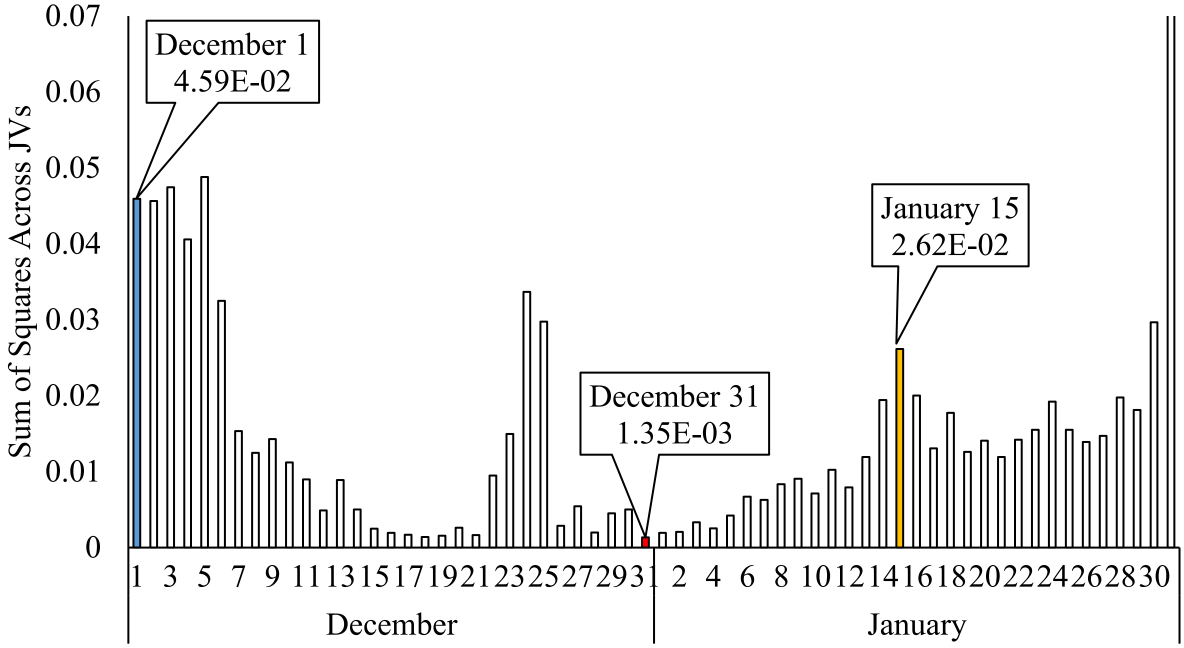


Figure 7. Daily sum of squares values for mallards during winter. The sum of squares value is minimized on December 31, thus representing the most precise anchor point.

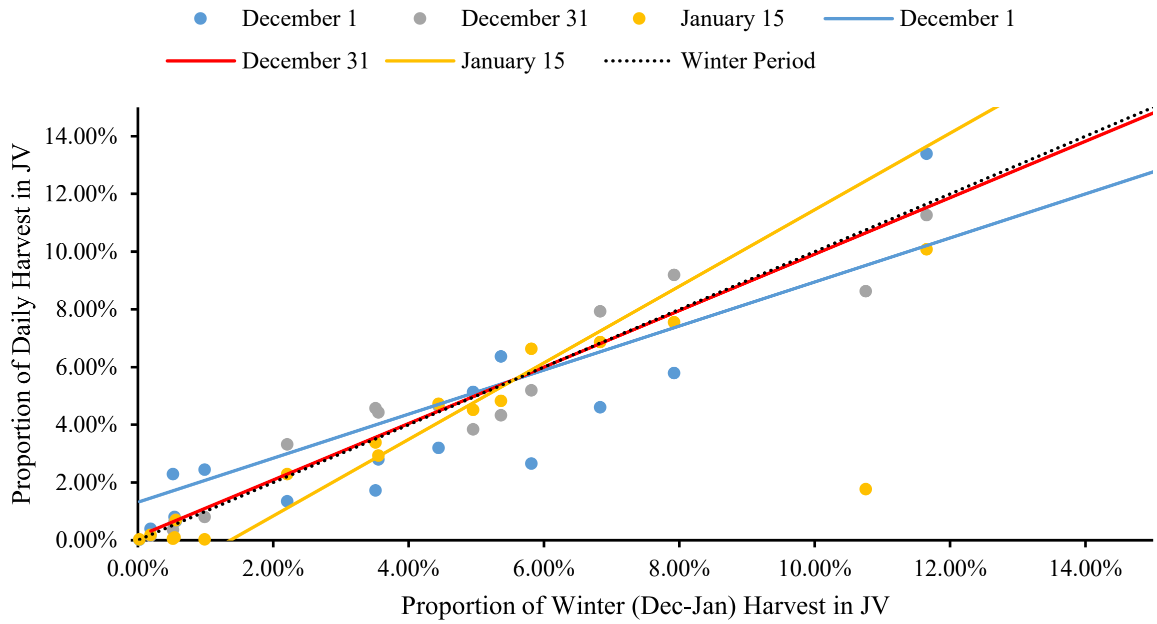
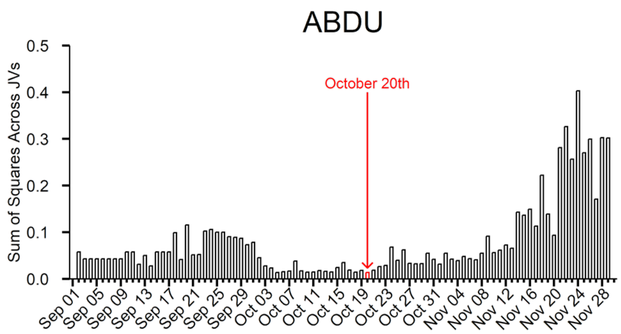
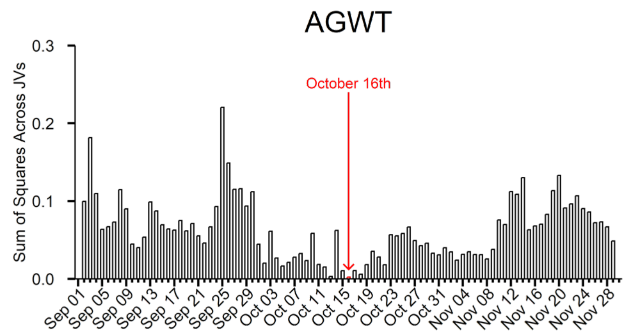


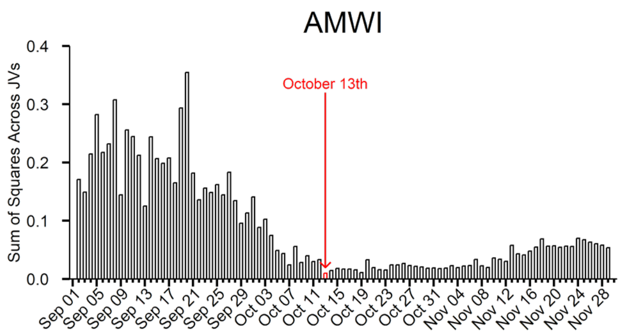
Figure 8. Relationship between the proportional distribution of mallard harvest on three example dates in the winter period versus the proportional distribution of harvest across the entire period. The black dotted line represents a perfect 1:1 relationship where daily harvest distribution among joint ventures is identical to the distribution of harvest across JVs during the entire winter period (December 1-January 31). Each point represents the relationship for a single JV whereas, the line of best fit represents the distribution across JVs.

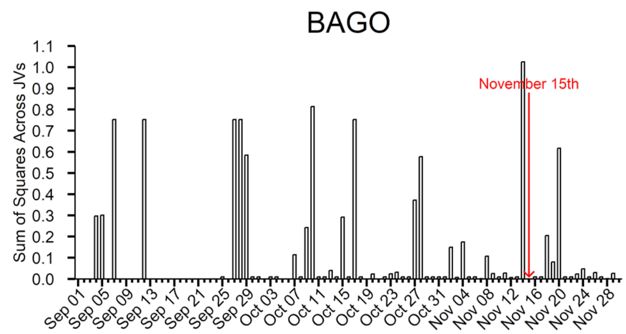
APPENDIX 1 – Species Specific Sum of Squares Graphs

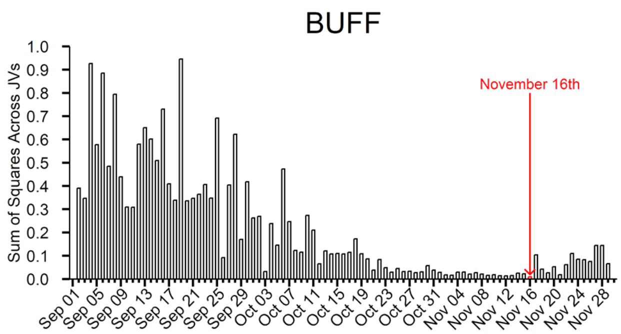
AUTUMN

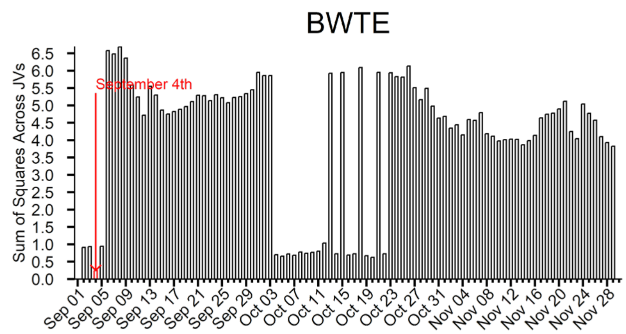


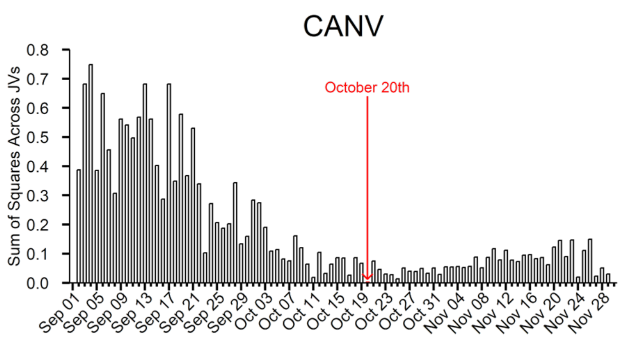


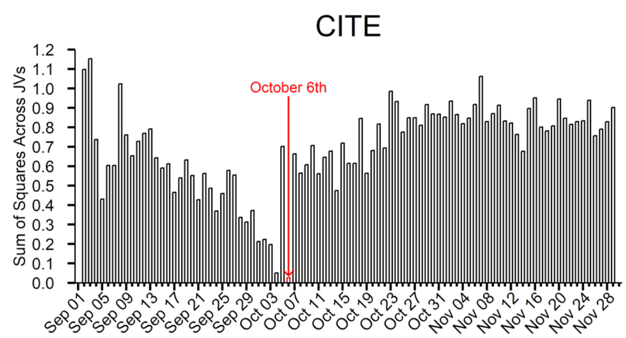


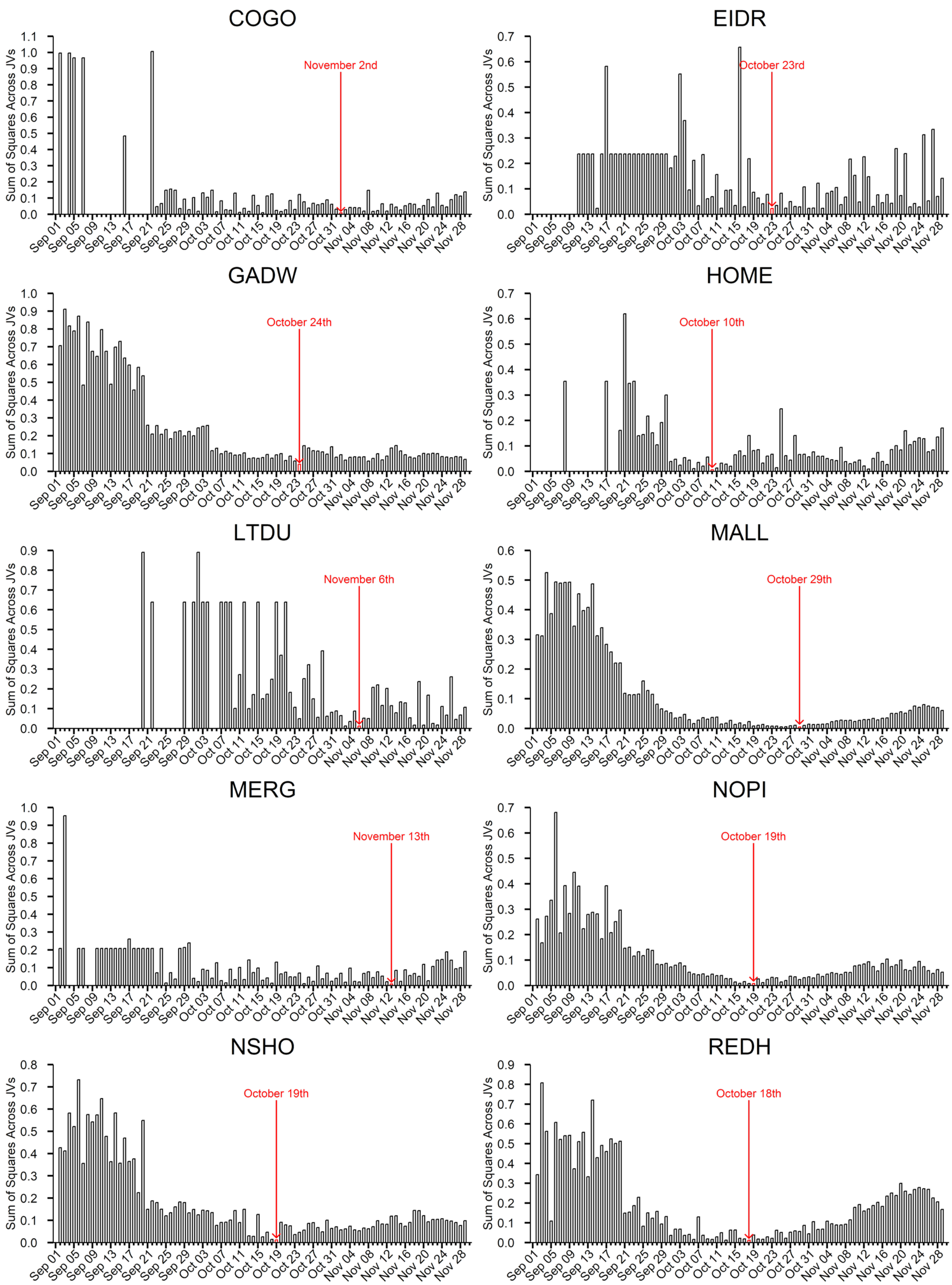


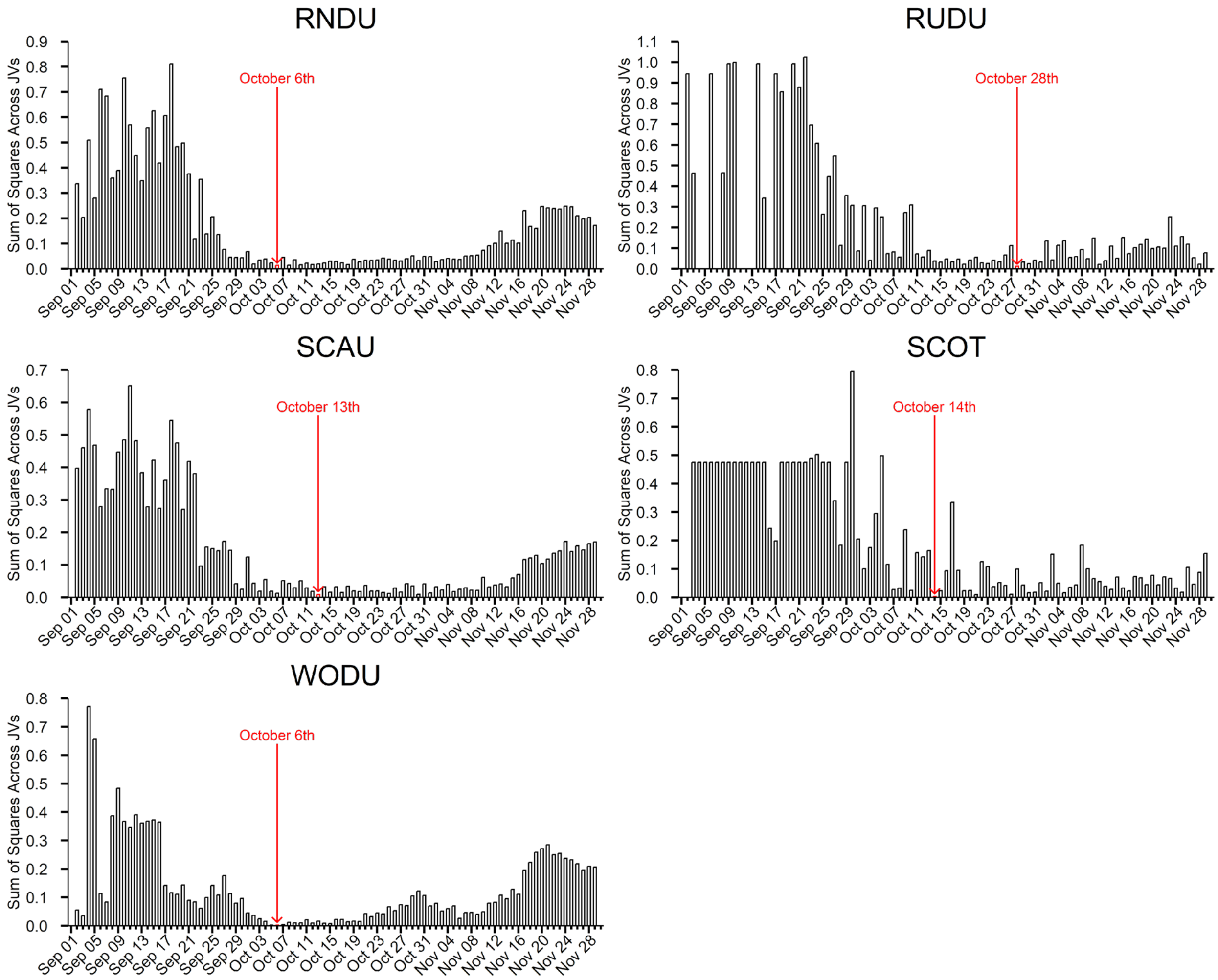






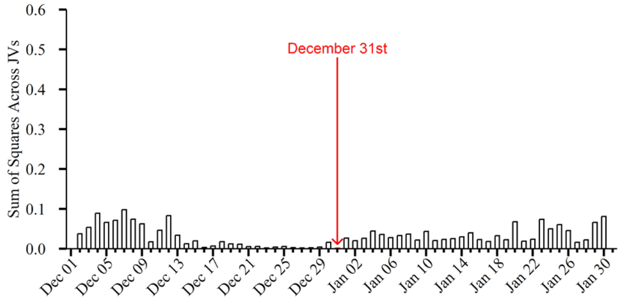



COGO
November 2nd
EIDR
October 23rd
GADW
October 24th
HOME
October 10th
LTDU
November 6th
MALL
October 29th
MERG
November 13th
NOPI
October 19th
NSHO
October 19th
REDH
October 18th
Sum of Squares Across JVs
Sep 01
Sep 05
Sep 09
Sep 13
Sep 17
Sep 21
Sep 25
Sep 29
Oct 03
Oct 07
Oct 11
Oct 15
Oct 19
Oct 23
Oct 27
Oct 31
Nov 04
Nov 08
Nov 12
Nov 16
Nov 20
Nov 24
Nov 28

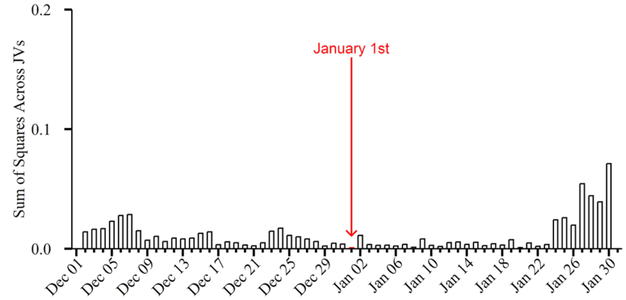

RNDU
Sum of Squares Across JVs
October 6th
RUDU
October 28th
SCAU
October 13th
SCOT
October 14th
WODU
October 6th
Sep 01
Sep 05
Sep 09
Sep 13
Sep 17
Sep 21
Sep 25
Sep 29
Oct 03
Oct 07
Oct 11
Oct 15
Oct 19
Oct 23
Oct 27
Oct 31
Nov 04
Nov 08
Nov 12
Nov 16
Nov 20
Nov 24
Nov 28

WINTER

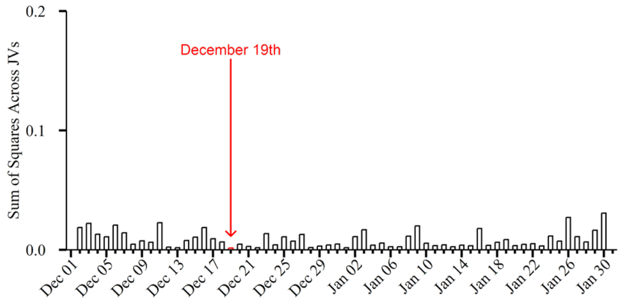
ABDU



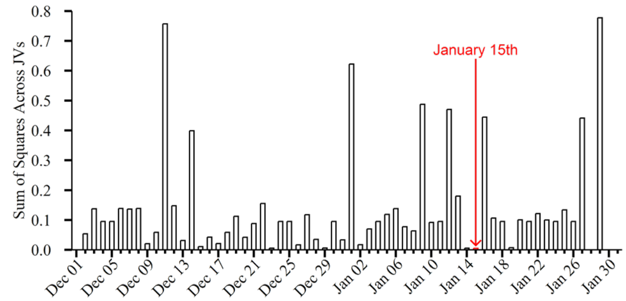
AGWT



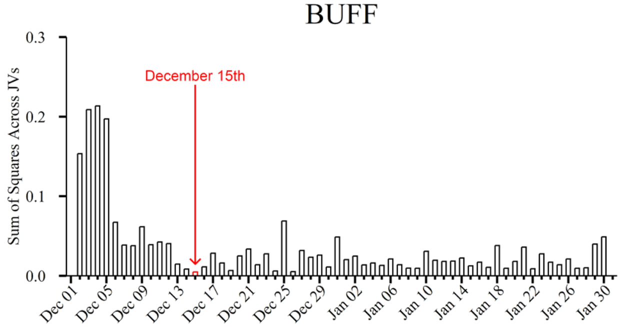
AMWI



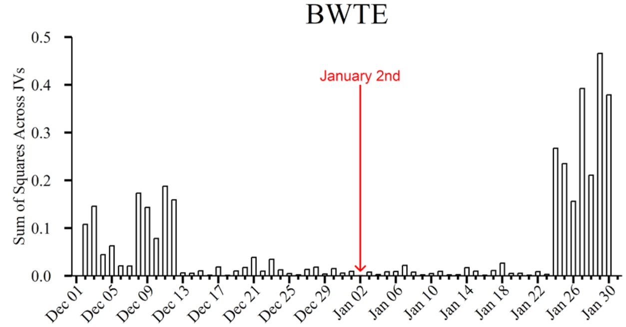
BAGO



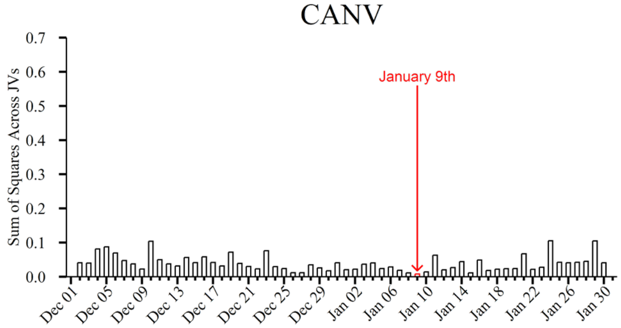
BUFF



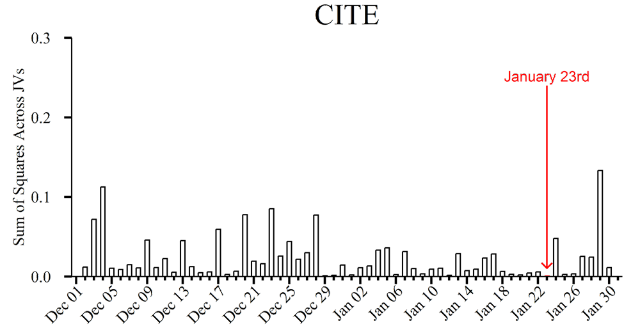
BWTE



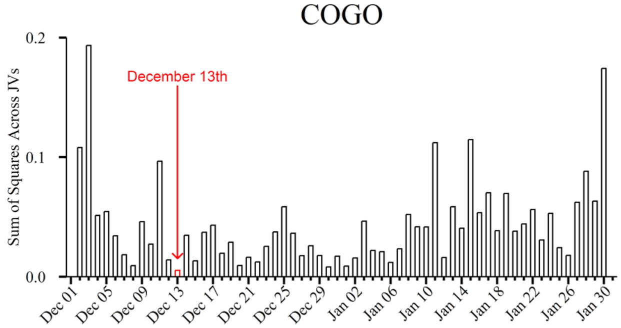
CANV



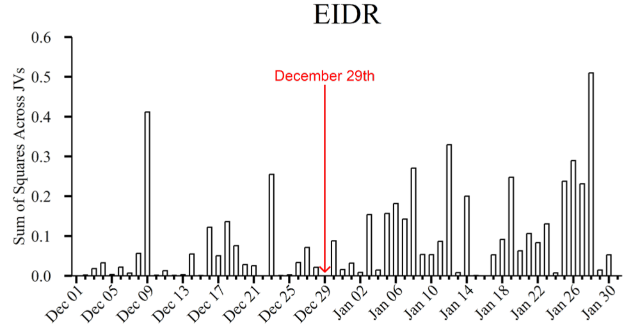
CITE

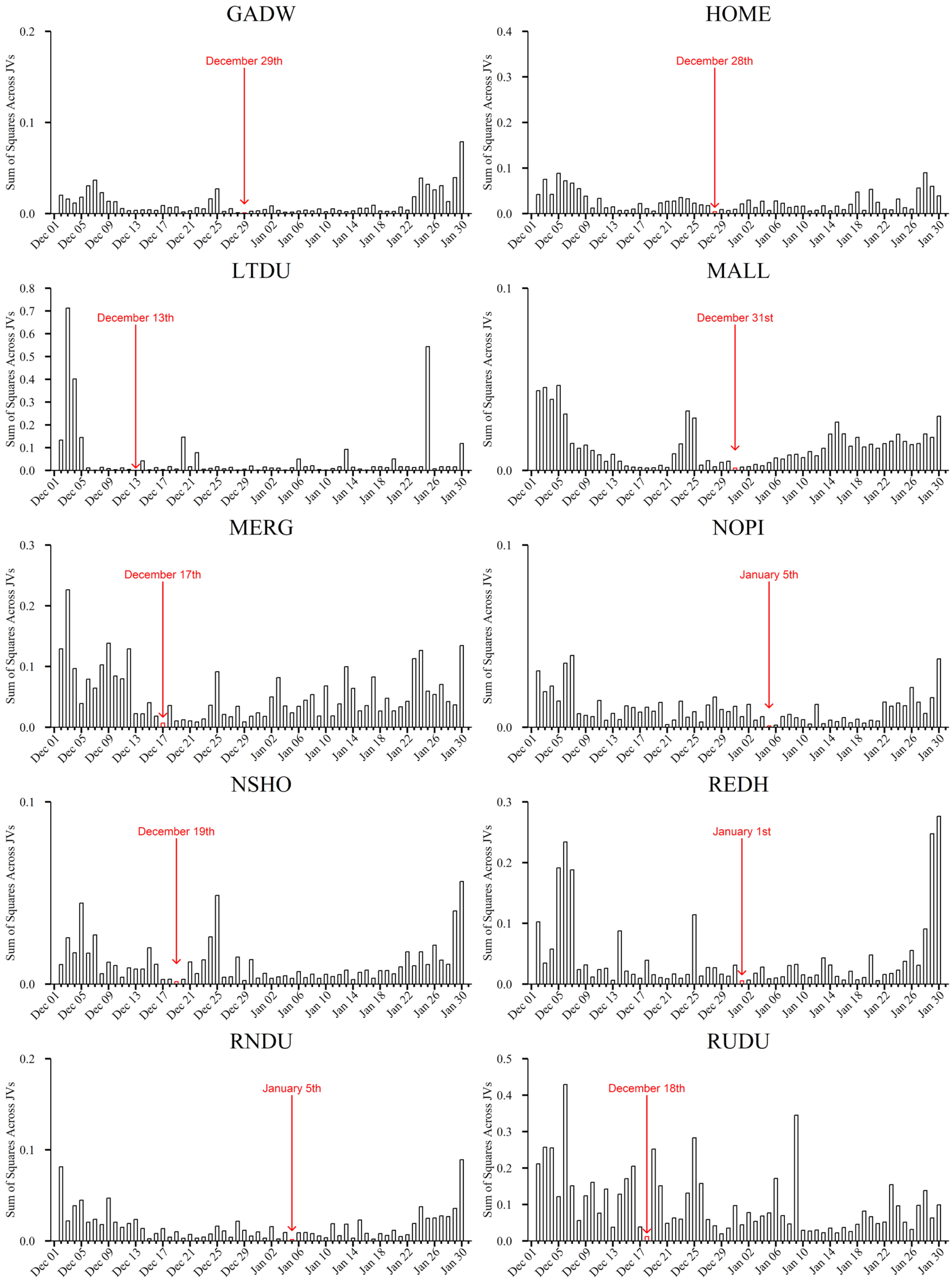


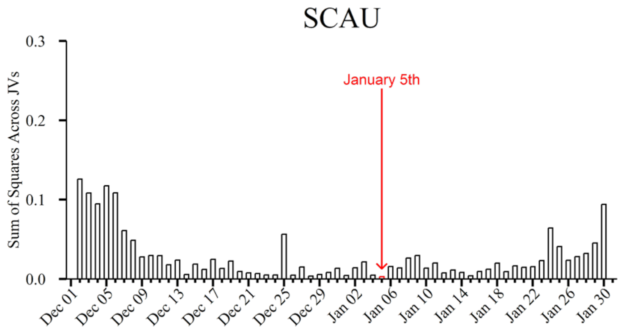
COGO

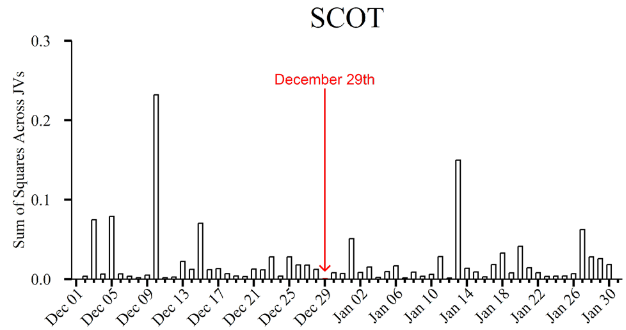


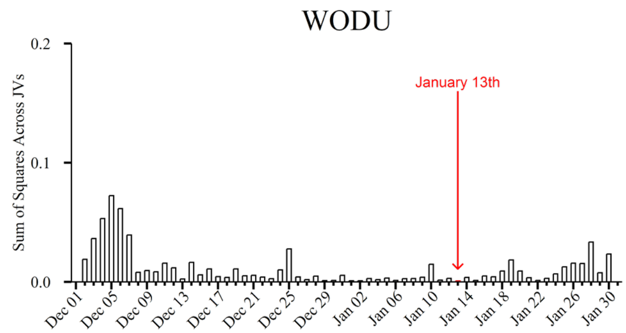
EIDR




GADW
December 29th
Sum of Squares Across JVs
HOME
December 28th
Sum of Squares Across JVs
LTDU
December 13th
Sum of Squares Across JVs
MALL
December 31st
Sum of Squares Across JVs
MERG
December 17th
Sum of Squares Across JVs
NOPI
January 5th
Sum of Squares Across JVs
NSHO
December 19th
Sum of Squares Across JVs
REDH
January 1st
Sum of Squares Across JVs
RNDU
January 5th
Sum of Squares Across JVs
RUDU
December 18th
Sum of Squares Across JVs
Dec 01
Dec 05
Dec 09
Dec 13
Dec 17
Dec 21
Dec 25
Dec 29
Jan 02
Jan 06
Jan 10
Jan 14
Jan 18
Jan 22
Jan 26
Jan 30


SCAU
Sum of Squares Across JVs
January 5th
0.3
0.2
0.1
0.0
Dec 01
Dec 05
Dec 09
Dec 13
Dec 17
Dec 21
Dec 25
Dec 29
Jan 02
Jan 06
Jan 10
Jan 14
Jan 18
Jan 22
Jan 26
Jan 30


SCOT
Sum of Squares Across JVs
December 29th
0.3
0.2
0.1
0.0
Dec 01
Dec 05
Dec 09
Dec 13
Dec 17
Dec 21
Dec 25
Dec 29
Jan 02
Jan 06
Jan 10
Jan 14
Jan 18
Jan 22
Jan 26
Jan 30


WODU
Sum of Squares Across JVs
January 13th
0.2
0.1
0.0
Dec 01
Dec 05
Dec 09
Dec 13
Dec 17
Dec 21
Dec 25
Dec 29
Jan 02
Jan 06
Jan 10
Jan 14
Jan 18
Jan 22
Jan 26
Jan 30