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[p / doi . /10.1038 / 1 -01 -0 1-](https://doi.org/10.1038/s41467-019-09971-8)

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Stochastic simulations reveal few green wave surfing populations among spring migrating herbivorous waterfowl

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Tracking seasonally changing resources is regarded as a widespread proximate mechanism underpinning animal migration. Migrating herbivores, for example, are hypothesized to track seasonal foliage dynamics over large spatial scales. Previous investigations of this green wave hypothesis involved few species and limited geographical extent, and used conventional correlation that cannot disentangle alternative correlated effects. Here, we introduce stochastic simulations to test this hypothesis using 222 individual spring migration episodes of 14 populations of ten species of geese, swans and dabbling ducks throughout Europe, East Asia, and North America. We find that the green wave cannot be considered a ubiquitous driver of herbivorous waterfowl spring migration, as it explains observed migration patterns of only a few grazing populations in specific regions. We suggest that ecological barriers and particularly human disturbance likely constrain the capacity of herbivorous waterfowl to track the green wave in some regions, highlighting key challenges in conserving migratory birds.

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L

The image shows a page of musical notation, likely a score for a piece of music. A large, bold, red letter 'L' is positioned in the upper left corner. The page is filled with musical staves, each containing notes, rests, and other musical symbols. Several dynamic markings are visible, including 'fi' (f marcato), 'y', and 'y.'. There are also some parentheses and other symbols scattered throughout the notation. The overall appearance is that of a printed musical score page.

$y = \dots | \bullet | \dots | y | \dots | \bullet | \dots |$

This image shows a complex musical score, likely a piano or organ arrangement, consisting of approximately 12 staves. The notation is dense and includes various musical symbols such as notes, rests, and dynamic markings. Key markings include 'y', 'fi', and 'x' scattered throughout the score. The score is written in a traditional musical notation style with a treble clef on the top staff. The overall appearance is that of a professional musical manuscript or a high-quality printed score.

fi . y ()

y)

y () y

y y

fi y x

y

y

fi y

This image shows a page of musical notation, likely a score for a string ensemble or orchestra. The notation is arranged in several staves, with various musical symbols and markings. Key features include:

- Dynamic Markings:** The notation includes several instances of the fortissimo marking "ff" and the accent marking "y".
- Articulation:** There are numerous slurs and accents throughout the score, indicating phrasing and emphasis.
- Structural Markings:** Some measures are enclosed in parentheses, possibly indicating first and second endings or specific performance instructions.
- Staff Layout:** The notation is dense, with many notes and rests across the staves, suggesting a complex and rhythmic piece.

...y... () | ...y-
fi ... m) ...)
... (... fi ...
... y... y... y
...) y ... y
... y... ()
... y...) | ... y...)

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