**ҚАЗАҚСТАН РЕСПУБЛИКАСЫ БІЛІМ ЖӘНЕ ҒЫЛЫМ МИНИСТРЛІГІ**

**АХМЕТ БАЙТҰРСЫНҰЛЫ АТЫНДАҒЫ ҚОСТАНАЙ ӨҢІРЛІК УНИВЕРСИТЕТІ**

**Ө. СҰЛТАНҒАЗИН АТЫНДАҒЫ ПЕДАГОГИКАЛЫҚ ИНСТИТУТЫ**

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**Қостанай мемлекеттік педагогикалық институтының құрметті профессоры, биология ғылымдарының докторы Т.М. Брагинаның мерейтойына арналған**

# БИОЛОГИЯЛЫҚ ӘРТҮРЛІЛІКТІ САҚТАУ ЖӘНЕ ЕРЕКШЕ ҚОРҒАЛАТЫН ТАБИҒИ АУМАҚТАР ЖЕЛІСІН ДАМЫТУ атты

**ХАЛЫҚАРАЛЫҚ ҒЫЛЫМИ-ПРАКТИКАЛЫҚ КОНФЕРЕНЦИЯНЫҢ**

# МАТЕРИАЛДАРЫ


# МАТЕРИАЛЫ

**МЕЖДУНАРОДНОЙ НАУЧНО-ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ**

# СОХРАНЕНИЕ БИОЛОГИЧЕСКОГО РАЗНООБРАЗИЯ И РАЗВИТИЕ СЕТИ ОСОБО ОХРАНЯЕМЫХ ПРИРОДНЫХ ТЕРРИТОРИЙ,

**посвященной юбилею почетного профессора Костанайского государственного педагогического института, доктора биологических наук Т.М. Брагиной**





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**OF THE INTERNATIONAL RESEARCH AND TRAINING CONFERENCE**

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**dedicated to the anniversary of the honorary professor of the Kostanay state pedagogical institute, doctor of biological sciences T.M. Bragina**

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# ПЛЕНАРЛЫҚ БАЯНДАМАЛАР. ЕРЕКШЕ КОРҒАЛАТЫН ТАБИҒИ АУМАҚТАР ЖЕЛІСІН ДАМЫТУ

# ПЛЕНАРНЫЕ ДОКЛАДЫ. РАЗВИТИЕ СЕТИ ОСОБО ОХРАНЯЕМЫХ ПРИРОДНЫХ ТЕРРИТОРИЙ

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## MONTHLY VARIATION IN HOME RANGE OF A STEPPE-DWELLING RAPTOR

***Месячные колебания ареала обитания степного хищника***

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**Аңдатпа.** Дала ландшафттарындағы құстар жылдық цикл кезінде мінез-құлқын өзгертеді. Біз GPS телеметриясын 10 ересек дала сұңқарларын (*Buteo regalis*) бақылау үшін қолдандық, олардың тіршілік ету ортасы жыл бойына қалай өзгергенін түсіну үшін. Аумақтық ересек сұңқарлардың үй ауқымының өлшемдері жыл ішіндегі күшті ауытқуларды көрсетті: ең аз сәуірден маусымға дейін және ең үлкен шілдеден қазанға дейін. Ареалдың ауқым өлшемінің үлгілері көбею уақыты мен көші-қон мінез-құлқы сияқты ішкі факторлармен, сондай-ақ өсімдік жамылғысының белгілі бір түрлерімен байланысты олжаның қолжетімділігі сияқты сыртқы факторлармен байланысты болуы мүмкін. Бұл нәтижелер дала құстарының өсімдік жамылғысының болжамды өзгерістеріне реакциясын түсінуімізге әсер етеді және адам әрекеті мен жабайы жануарлардың мінез-құлқы арасындағы әлеуеттік байланысты болжайды. Біз бақылаған құстар Солтүстік Американың батысының көп бөлігін қамтиды, сондықтан бұл даралар тұзақ қойған шағын аумақтан тыс жерде хабардар болуы мүмкін**.**

**Түйінді сөздер:** *Buteo regalis*, безді сұңқар.

**Abstract.** Birds in steppe landscapes change their behaviour over the annual cycle. We used GPS telemetry to track 10 steppe-dwelling adult Ferruginous Hawks (*Buteo regalis*) to understand how their home ranges varied across the year. Home range sizes of territorial adult hawks showed strong intra-annual variation, being smallest from April to June, and largest from July to October. Patterns in home range size were likely linked to intrinsic factors such as the timing of breeding and migratory behaviour, and to extrinsic factors such as prey availability associated with specific landcover types. These results have implications for our understanding of the response of steppe birds to predicted changes in land cover, and they suggest potential relationships between human activity and wildlife behaviour. Because the birds we tracked used a large portion of western North America, they are likely informative far beyond the small area where these individuals were trapped.

**Key words:** *Buteo regalis*, Ferruginous hawk, home range, seasonal variation.

**Аннотация.** Птицы в степных ландшафтах меняют свое поведение в течение годового цикла. Мы использовали GPS-телеметрию, чтобы отследить 10 взрослых степных ястребов (*Buteo regalis*), чтобы понять, как их ареал обитания менялся в течение года. Размеры домашнего ареала территориальных

взрослых ястребов демонстрировали сильные внутригодовые колебания: наименьшие с апреля по июнь и наибольшие с июля по октябрь. Модели размера ареала, вероятно, были связаны с внутренними факторами, такими как время размножения и миграционное поведение, а также с внешними факторами, такими как доступность добычи, связанная с конкретными типами растительного покрова. Эти результаты имеют значение для нашего понимания реакции степных птиц на прогнозируемые изменения растительного покрова и предполагают потенциальную связь между деятельностью человека и поведением диких животных. Поскольку птицы, которых мы отслеживали, использовали большую часть западной части Северной Америки, они, вероятно, информативны далеко за пределами небольшой территории, где эти особи оказались в ловушке.
**Ключевые слова.** *Buteo regalis*, королевский канюк.

**Introduction**. Animal movement is driven by a suite of processes acting across a variety of spatial and temporal scales (Nathan et al. 2008). For example, across the annual cycle, migratory species travel widely between well dispersed areas (Klaassen et al. 2014), and even non-migratory animals tend to show intra-annual variation in movement behaviours (van Beest et al. 2013). Birds, in particular, are exposed to different sets of processes and stressors during breeding, migration, and non-breeding periods (Sillett and Holmes 2002). Despite this, monitoring of many migratory species is typically limited to only one of these annual periods (Marra et al. 2015). That said, understanding threats and limits to populations throughout the annual cycle is important to guide conservation measures, especially for migratory species (Sillett and Holmes 2002, Klaassen et al. 2014, Marra et al. 2015). As such, by collecting movement data on birds, we can begin to understand and manage for their interactions with the landscape and climate across large spatial scales.

Home range, the area where activities such as foraging, breeding, and rearing young occur (Burt 1943), is often evaluated to identify habitats relevant to the survival of a species. Therefore, unbiased estimates of intra-annual variation in home range size can help to inform which factors are correlated with long term population stability. Improving home range estimates during all times of the year is also useful because knowing the size and location of home ranges can help to assess responses to intra-annual changes to the natural environment.

We evaluated monthly variation in home range of a steppe raptor, the Ferruginous Hawk (*Buteo regalis*), breeding in southwest Idaho, USA. Our overall goal was to better understand patterns of movement ecology and use of space by this species across the annual cycle. To do this, we evaluated month to month cycles in size of home range of this species across the year.

**Methods**

*Study site & focal species*

Ferruginous Hawks are diurnal raptors that occupy arid grasslands, shrub-steppe, and high-altitude deserts across western North America, from Canada to Mexico (Ng et al. 2020). This steppe-dwelling species typically is highly dependent on ground squirrels (*Sciuridae* spp.) and other small rodents for food (Schmutz and Fyfe 1987). Ferruginous Hawk migration is typically non-linear, with birds first migrating longitudinally, possibly responding to variation in rodent abundance, before completing their migration south (Ng et al. 2020). This raptor species is classified as vulnerable, imperilled, or critically imperilled in 18 of the 21 states and provinces across its range in the United States and Canada (NatureServe 2021).

We studied Ferruginous Hawks that nested within the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA), in the state of Idaho, USA (Fig. 1A). At this site, Ferruginous Hawks typically arrive on territories during March, before laying eggs in mid-April (Howard 1975). Nestlings typically fledge in June and all birds depart from the natal site, usually traveling to Canada, in late July-August.

*Capture & GPS data collection*

To capture free-flying Ferruginous Hawks, we used mist nets and a robotic Great Horned Owl (*Bubo virginianus*) lure placed near the nest (Jensen et al. 2019). To capture nestlings, we removed them from the nest by hand. Adult birds were fitted with 30-g CTT-1030-BT3 Series GPS-GSM telemetry devices (Cellular Tracking Technologies, Rio Grande, NJ, USA). The units were programmed to collect GPS locations, altitude, speed, fix quality (2D or 3D fix), and horizontal and vertical dilution of precision (HDOP and VDOP), at 15-minute intervals during daylight hours throughout spring, summer, and autumn months. During the winter, interval length was increased (up to 6-hour intervals) due to reduced solar energy limiting recharging of batteries. Data collected were sent to a server via the GSM mobile phone network once per day. Nestling birds were fitted with 22-g Argos/GPS solar-powered Platform Transmitter Terminals (PTT; Microwave Telemetry, Inc., Columbia, MD, USA) that collected GPS locations, altitude, speed and fix quality at 3-h intervals, year-round. Prior to analysis we removed poor quality GPS points indicated by 2D fix quality (Poessel et al. 2018). We also removed points for which the horizontal or vertical dilution of position (HDOP or VDOP) was >10 (D'Eon and Delparte 2005). We calculated user equivalent range errors (UERE) from GPS points collected while devices were in a static position for a period of 17-30 days using the ctmm package in R (Noonan et al. 2019; R Core Team 2021) and we excluded fixes that were collected after sunset but before sunrise.

*Monthly home range size*

We estimated home range area for each bird in each month, using autocorrelated kernel density estimators (AKDEs) implemented in the ctmm package in R (Fleming et al. 2015; Calabrese et al. 2016; Noonan et al. 2019; R Core Team 2021). Calculating bird home range for each month allowed us to evaluate changes in home range size throughout the annual cycle, as well as to compare home range size between seasons. AKDEs are also useful because they control for irregular and uneven sampling rates.

We only estimated home range for bird-months where birds were range resident for ≥8 days and with ≥30 GPS points. Consequently, all periods of migration, including short migratory stopovers, were excluded from any analysis. During those months where birds were only partially range resident (i.e., spent a portion of the month wandering), we estimated home range using only the days when the bird was range resident. When birds established range residency in >1 area within the same month, we used the separate home range estimates to calculate a mean that we weighted by the duration spent in each home range.

*Statistical modelling*

We evaluated intra-annual (monthly) variation in home range size throughout the year using a generalised additive mixed model (GAMM; R package mgcv; Wood et al. 2016). We had one fixed in effect in our model, bird sex, and one random effect, individual bird identity. We tested model performance with and without a random effect for year, to account for response of birds to year-to-year variation. We fitted a cyclic smoothing spline to the month term in the model to capture non-linear relationships associated with this numerical term. As our data were continuous and zero bounded, we used the Gamma error family with a log link function.

**Results.** We evaluated GPS data from eight Ferruginous Hawks (five female, three male) captured as adults and two adult females captured as nestlings. Over the study period (May 2016 – Apr 2021), and after filtering described above, we considered 139,984 high-quality GPS locations collected during daytime across western North America (Fig. 1A,B,C). Individual birds were tracked from one to 35 months. After removing bird-months for which data were sparse, we estimated home ranges for 182 bird-months, with 11 to 20 home ranges per month.

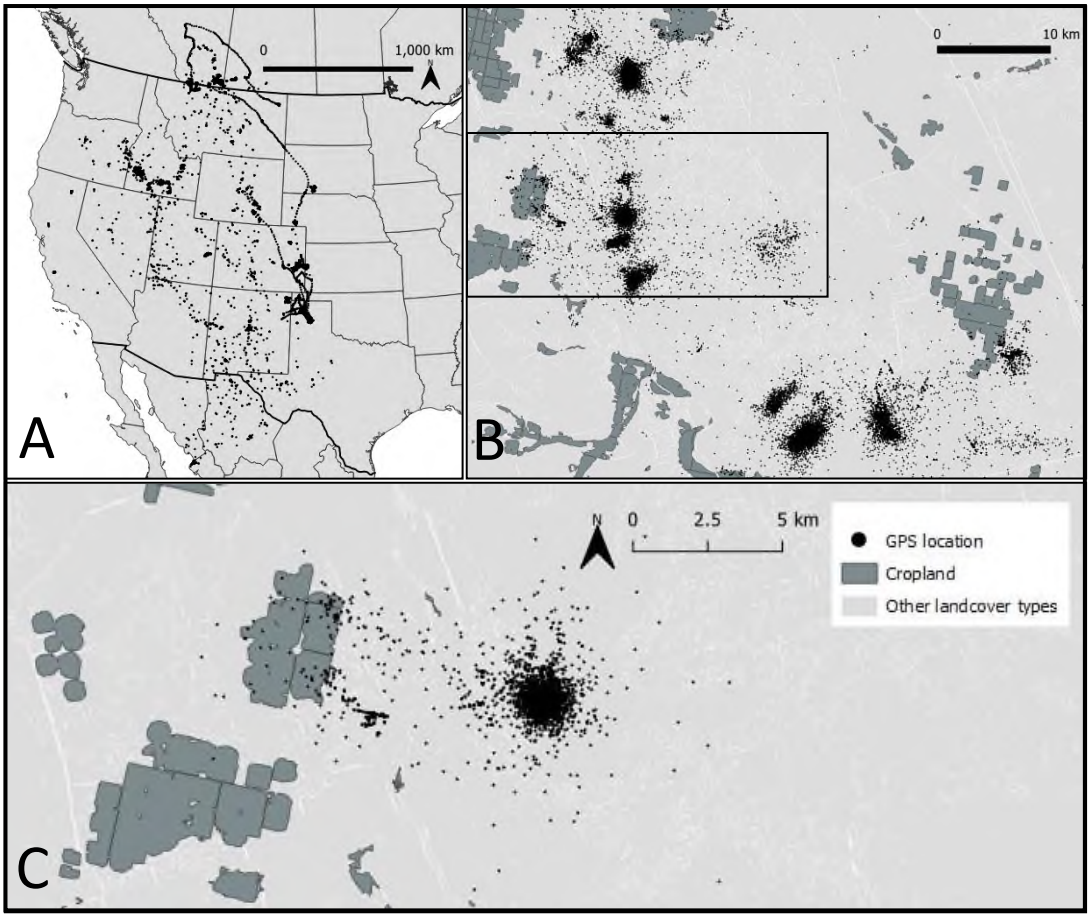


Fig. 1 – GPS locations of Ferruginous Hawks (black dots) **A)** tracked from their breeding location in Southwest Idaho from 2016 to 2021 across North America (*n* = 12); **B**) tracked throughout their breeding area in the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA), Idaho; and **C**) a single individual tracked throughout the NCA during one breeding season. Dark grey patches show the distribution of cropland where hawks sometimes foraged and black box shows area shown in panel C.

*Monthly home range size*

Monthly home range size of adults during the breeding season (March – July) ranged from 0.01 to 3723.59 km$^2$ (115.81 ± 55.94; $\bar{x}$ ± SE; *n* = 10 birds, 76 bird months) and, outside of the breeding season (August – February), from 0.55 to 4085.41 km$^2$ (223.96 ± 50.05; *n* = 9, 106). There was a non-linear association between month and average home range size (i.e., the spline of month was highly significant; effective degrees of freedom (edf) = 4.54, *p* = <0.001; Fig. 2). Home range size was smallest during the breeding season months of May (2.59 ± 1.01 km$^2$, *n* = 8,15), June (9.65± 2.26 km$^2$, *n* = 10, 21) and April (24.94 ± 23.18 km$^2$, *n* =8, 13; Fig. 2). In contrast, empirical means of home rages were largest during July (412.52 ± 216.78 km$^2$, *n* = 9, 20) and October (277.54 ± 119.50 km$^2$, *n* =9, 19; Fig. 2). Overall, home range size in three months of the breeding season (April-June) was significantly smaller than during three months of the wintering season (November-January; *p* = <0.001). Monthly home range size of Ferruginous Hawks was different among the sexes, with males having slightly smaller home ranges than females ($\beta$ = -1.30; *p* = 0.04). Including a random effect for year reduced model performance, and so we did not use such a term in our modelling efforts.

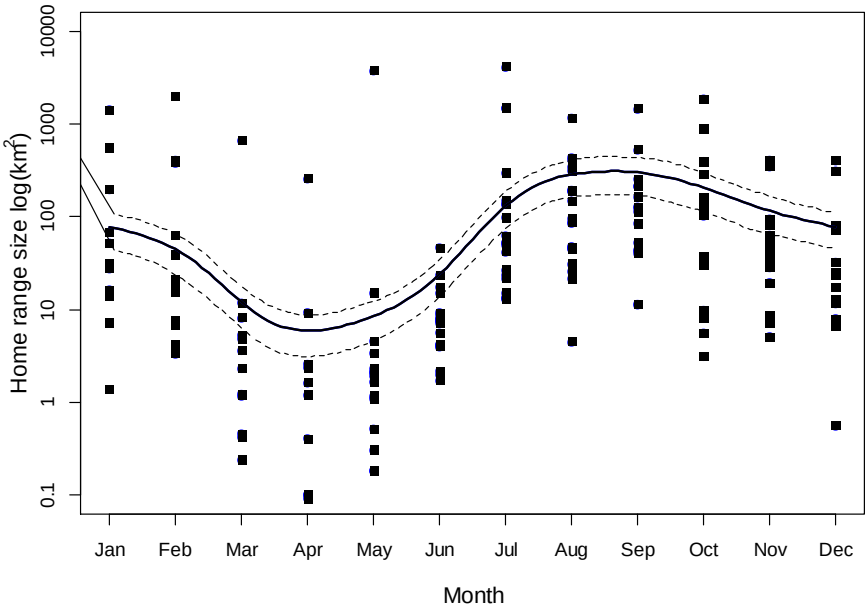


Fig. 2 – Generalised additive mixed model and 95% confidence intervals showing effect of month on mean monthly home range of Ferruginous Hawks (95% autocorrelated kernel density estimation, *n* = 10 adults hawks and 182 bird-months) tracked between 2016 and 2021 in North America.

**Discussion**. Ranging behaviour of animals responds to intrinsic factors such as age, sex, and breeding status, as well as extrinsic factors such as seasonality and resource availability. The patterns we observed, with the smallest home ranges during the months of the breeding season and larger home ranges at other times of year, fit our expectations for how territorial and migratory species behave. Similar to other raptor species, adult Ferruginous Hawks appeared as central place foragers that stayed close to the nest site during breeding months, presumably to defend their territory and rear young (Moss et al. 2014, Miller et al. 2017, Ng et al. 2020). The larger home ranges we observed during the wintering season could have been linked to reduction in habitat quality due to changes in factors such as prey availability (Moss et al. 2014), or reduction in defensive behaviour and sharing of resources (Grande et al. 2009).

There are two notable caveats to our inference regarding response to these resources. First, we were not able to test how variation in food availability between years may have influenced movement of these hawks. We expect that during years with less abundant food resources, home range sizes would be larger. Second, the sex-specific differences in home range size of these birds is notable. Such differences are detected for some adult raptors (female Red Kites *Milvus milvus* and Golden Eagles *Aquila chrysaetos* had larger home ranges than did males; Spatz et al. 2022, Braham et al. 2015; male Montagu's Harriers *Circus pygargus* have larger home ranges than do females; Krupiński et al. 2021), but not for others (Golden Eagles in Miller et al. 2017). In this case, it is unclear exactly what factors may have resulted in the sex-related differences we detected in ranging behaviour.

Although Ferruginous Hawks are widespread in western North American steppe habitats, their biology is poorly understood. The novel tracking technologies we deployed to track these birds thus provided new insight into their behaviours that may help their management in the future.

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## CONSERVATION AT A CROSS-ROADS

### *Сохранение на перекрестках*

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**Аңдатпа.** Табиғатты қорғаудың екі көрінісі биоалуантүрлілік туралы конвенциядан (БҰҰ КБР) келді. Куньмин-Монреаль 2030 жылға қарай жердің 30% -. қорғауды ұсынады ("30х30"төмендеу тәсілін қолдану арқылы). Биоалуантүрлілік және Экожүйелік қызметтер жөніндегі үкіметаралық ғылыми-саяси платформа (МПБЭУ) Біріккен Ұлттар Ұйымының Тұрақты даму мақсаттарына қол жеткізу үшін адамзаттың үштен бірінің жабайы тірі ресурстарға тәуелділігін пайдалануды ұсынады. Бұл идеялардың шектен шығуы "археологиялық жер" және "жер-бақ"планетасының болашағына әкелуі мүмкін екендігі атап өтілді. "Төменнен жоғары" тәсіл үшін автоматтандырылған нұсқаулықты пайдалану табиғатты сақтау үшін де, кеңірек басқару үшін де қанағаттанарлық болуы мүмкін.
**Түйінді сөздер:** сақтау, басқару, шешім қабылдауды қолдау, Жер Археологиясы, Жер-Бақ.

**Аннотация.** Два видения сохранения пришли из Конвенции по биоразнообразию (КБР ООН). Куньмин-Монреаль рекомендует защитить 30% земель к 2030 году (навязывая нисходящий подход «30х30»). Межправительственная научно-политическая платформа по биоразнообразию и экосистемным услугам (МПБЭУ) предлагает использовать зависимость почти трети человечества от диких живых ресурсов для достижения Целей устойчивого развития Организации Объединенных Наций. Отмечается, что доведение этих представлений до крайности может привести к будущему планеты «Археологическая Земля» и «Земля-сад». Использование автоматизированного руководства для подхода «снизу вверх» может быть более удовлетворительным как для сохранения природы, так и для более широкого управления.
**Ключевые слова:** сохранение, управление, поддержка принятия решений, Археология Земли, Земля – Сад.

**Abstract.** Two visions of conservation have come from the UN’s CBD. Kunming-Montreal recommends protection for 30% of the earths land by 2030 (imposing a top-down ‘30x30’ approach). IPBES proposes that the dependence of close to a third of humans on wild living resources should be used to help achieve the Sustainable Development Goals of the United Nations. It is noted that taking these visions to extremes could result in ‘Archology Earth’ and ‘Garden Earth’ futures for the planet. Using automated guidance for a bottom-up approach may be more satisfactory both for conservation and governance more widely.
**Key words:** Conservation, governance, decision-support, Arcology Earth, Garden Earth.

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# PROCEEDINGS

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