

Habitat relations of *Rhea americana* in an agroecosystem of Buenos Aires Province, Argentina

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Abstract

The maintenance of wild populations of Greater Rhea (*Rhea americana*) through effective management requires an understanding of their habitat requirements in terms of vegetation composition and field configuration. We studied the relative influence of some anthropogenic variables (presence of route, house and fences) and resource variables (presence of water source, composition and coverage of plant species, vegetation height and bare soil), on the habitat use by a population of rheas in a cattle ranch of Buenos Aires Province, Argentina. Habitat use was determined indirectly by documenting the number of faeces in summer, autumn–winter and spring 1999. The presence or absence of faeces was related to the measured variables through discriminant analysis that allowed the elaboration of predictive models of habitat use by this species. Contrary to what was expected, those variables related to human activity showed a low predictive value on the habitat use by rheas when compared with resource variables. Rheas preferentially selected the stream area in all seasons and sites with great percent cover of *Bupleurum* sp., *Phyla canescens*, *Sida leprosa*, *Plantago lanceolata*, *Trifolium repens*, *Lolium multiflorum*, *Stipa* spp., and *Stenotaphrum secundatum*. Low vegetation height was another important component of rhea's habitat in summer and autumn–winter. The high accuracy level obtained by validation tests of this model supports its utility for the management of rhea populations in other cattle ranches of the region, and to analyze the suitability of other ranches for reintroduction programs.

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1. Introduction

Analysis of habitat use is among the most important aspects of wildlife science. Central to the study of animal ecology is the use an animal makes of its environment; specifically, the foods it consumes and the diversity of habitats it occupies (Johnson, 1980). In the selection of a given habitat, the availability of resources is an important factor. Many studies have tested the relative effects

of multiple habitat attributes, showing that species select habitats according to nutritional demands, forage quality and risk of predation (Schaefer and Messier, 1995; Bowyer et al., 1998; Roguet et al., 1998). In addition, habitat selection may be influenced by features associated with landscape structure, such as floristic composition, plant distribution, water sources, topography and predation risk (Senft et al., 1987; Roguet et al., 1998). Detection of key habitat attributes on the basis of habitat-selection studies has a particular value for conservation objectives under pristine or nearly pristine conditions (Frid, 1994). Habitat fragmentation and modification by human activities also affect the selection of habitat and are responsible for the decrease and extinction of natural populations (Wilcox and Murphy, 1985; Saunders et al., 1990).

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Natural grasslands are one of the most human-modified and poorly protected biomes of the world, so conservation of their endangered species relies strongly on private ranches. One of such species is the Greater Rhea, *Rhea americana* (hereafter “rhea”), a South American ratite whose different subspecies inhabit Paraguay; E of Bolivia; NE, SE and SW of Brazil; Uruguay and north and central plains of Argentina. This ratite is a characteristic bird of the tall grass steppe of the *pampas*, but it also occupies several other savannah-type habitats, such as those in the Chaco zone (Folch, 1992).

The main threat that rheas face is the reduction of their habitat due to the conversion of grasslands to farmlands (Folch, 1992) and their indiscriminate hunting (Bucher and Nores, 1988). Since the 19th century, rheas have been pursued commercially, both for their feathers and leather, and as a source of food for man. In Argentina, wild populations of rheas are restricted to some protected areas and extensive cattle ranches, in many cases protected by their owners (Carman, 1973). In the last 10 years the species has begun to be commercially produced, although the captive stock of animals is still very low (Navarro and Martella, 2002).

The maintenance of wild populations of rheas through effective management requires an understanding of their habitat requirements in terms of vegetation composition and field configuration. In addition, due to agricultural and farming features of the *pampas* region as well as the lack of protected grassland areas, the implementation of conservation actions on this species strongly depends on a better understanding of the habitat value of different man-modified landscapes.

In this research, we present a description of the habitat use of a population of rheas in one of the few cattle ranches of Buenos Aires Province dedicated to the conservation of this species. The main objective of this study was to analyze the relative influence of some anthropogenic variables (presence of route, house and fences) and resource variables (presence of water source, composition and coverage of different plant species, mean vegetation height and percentage of bare soil), on the habitat use of a wild population of rheas in a cattle ranch of Buenos Aires Province. Species composition was considered an important attribute because most of the rhea's diet consists of plant organs such as leaves, seeds, fruits and roots (Debbene, 1920; Folch, 1992); however, they also consume insects and small vertebrates (Raikow, 1968; Folch, 1992; Martella et al., 1996; Comparatore and Martínez, 1997).

Habitat use was determined indirectly by documenting the number of faeces, an approach that has been used to estimate density and habitat use of large and medium sized animals (Litvaitis et al., 1985; Novaro et al., 1992; Hulbert et al., 1996; Schaefer and Messier, 1995). Intensive spatial quantification of faeces and measurements of both anthropogenic and resource

variables, allowed us to develop predictive models of habitat use by rheas. These models are proposed as flexible management tools for ranches where conservation of rhea is intended as a complementary objective to partial farming and cow-calf operations.

2. Methods

2.1. Study area

The study was carried out in a 4000-ha cattle ranch (Estancia Medaland, 37°25' S 57°12' W) in Buenos Aires Province, Argentina. In this establishment there is a natural population of rheas with a mean annual density of 0.22 individuals/ha (Comparatore and Martínez, 1997).

Potential vegetation structure in this agroecosystem corresponds to a pseudosteppe of grasses of 0.5–1 m height (Cabrera, 1976; Soriano et al., 1991). However, the constant grazing by large domestic herbivores has partially modified the original floristic composition and vegetation structure (Soriano et al., 1991). Communities that characterize the zone are the following: “flechillares” of *Stipa papposa* (“flechilla”); “juncales” of *Scirpus californicus* (“junco”), “pradera salada or distichletum” of *Distichlis spicata* and *Hordeum pusillum*; “hunquillares” of *Juncus acutus v. leopoldii*, “duraznilares” of *Solanum malacoxylon*; and in salty swamps, “espartillares” of *Spartina montevidensis* or *Spartina brasiliensis* (Vervoorst, 1967).

2.2. Data collection

During January to December 1999, three seasonal inventories were made in an area of 2700 ha (68% of the ranch area). Samples were taken in summer, autumn–winter and spring along seven transects perpendicular to the route. Sampling plots of 10 × 10 m at a mean distance of 440 m between each other, were located along the transects using GPS (70 in summer, 55 in autumn–winter and 57 in spring). The difference in the numbers of sampling plots was due to flood conditions in autumn–winter and spring, that impeded the access to some portions of the transects. The following variables were quantified in each sample plot: number of faeces; distance to route, house, fences and stream; vegetation cover per species using Domin-Krajima scale (Mueller-Dombois and ElleMBERG, 1974); mean canopy height at six random points within each sampling plot, and a visual estimation of percentage of bare soil. The faecal-pellet count method was used to estimate rhea habitat use because it results less erratic and shows better the process of general use of the habitat by the rhea population. Only fresh or semi-fresh faeces were counted; dry ones were not registered since they could have been

deposited the previous season. This criterion was the result of a qualitative study of decomposition time of the faeces performed as part of this work, in which fresh faeces were collected at the beginning of each season (17 in summer, nine in winter and 16 in spring), and were placed in protected sites out of the reach of domestic herbivores. The faeces were inspected every 15 days during three-month periods. Seven faeces in summer, four faeces in winter and three faeces in spring disappeared by the end of each three-month period, probably because of complete decomposition or transportation by wind, water or small mammals. Conserved faeces were not recognized as fresh relative to their condition at the beginning of each season. Instead, they appeared dry and semi-disintegrated, suggesting that faeces of this type encountered in sample plots were deposited in the previous season.

2.3. Data analysis

2.3.1. Discriminant analysis for two groups of faeces

Samples were classified into two groups according to the absence (G1) or presence (G2) of faeces. A discriminant analysis (DA) (Hair et al., 1995) was applied for each season to look for differences between both sample groups regarding the measured variables, and to determine which were the most important variables accounting for such differences. The significance of those differences was estimated through Student's *t* tests of the discriminant variables. Due to multicollinearity of some of the variables, the structure coefficient (SC) was used as a measure of the contribution of each variable in the separation of the faeces groups. Structure coefficients indicate how closely the input variables and the discriminant variables are related. When the absolute magnitude of the coefficient is large (i.e. approaching a value of one), the function is carrying nearly the same information as the variable. Conversely, when the coefficient is nearly zero, the function and the variable have little in common. As a consequence, those variables with the largest SC contributed most to the prediction of group membership (McGarigal et al., 2000). The class means of the canonical functions indicate that used sites (G2) are negatively correlated with the canonical function. This means that variables with negative structure coefficients are greater in magnitude on used sites, and variables with positive structure coefficients are lower in magnitude on used sites. Conversely, unused sites (G1) are positively correlated with the canonical function. The significance of the variables with large absolute SC was tested by simple correlations between each original variable and the discriminant variable.

2.3.2. Modeling habitat use

To produce a spatial model of habitat distribution, the discriminant variables (DV) obtained by DA above

described were applied to construct habitat use maps with SURFER software, using Kriging interpolation. A validation of the model using only summer data, which was the most complete data set (70 samples), was made according to the following criteria: 10 samples were eliminated at random of the pool of data (control points – three of them belonging to G1 and seven belonging to G2). DA was run with the remaining 60 samples. The canonical scores for each sample were obtained and the 95% confidence intervals for the scores around the mean of each pattern of habitat use (with or without faeces) were calculated. The unstandardized coefficients corresponding to each original variable were used to calculate the canonical scores of the 10 eliminated samples according to the following model (McGarigal et al., 2000):

$$h_{ij} = b_{i0} + b_{i1}x_{j1} + b_{i2}x_{j2} + \dots + b_{ip}x_{jp},$$

where h_{ij} is the score for the i th group and j th sample, b_{i0} is a constant for the i th group, b_{ik} is the classification coefficient for the i th group and the k th variable and x_{jk} is the value for the j th sample and k th variable. After this, and taking into account to which group of faeces each sample belongs, the calculated canonical scores of the eliminated samples were compared with the confidence interval calculated for the scores of each group.

3. Results

3.1. Relation between discriminant variables and the absence–presence of faeces

Number of faeces per sampling plot varied from 0 to nine in summer, from 0 to 10 in autumn–winter and from 0 to 13 in spring. Sampling plots with two and three faeces were more frequent in all seasons (Fig. 1).

The Student's *t* tests of the discriminant variables for each season were highly significant ($P < 0.001$ in all cases). Sites used by rheas (those with one or more faeces) in summer, were characterized by a greater percent cover of *Stenotaphrum secundatum*, *Phyla canescens*, *Sida leprosa* and *Plantago lanceolata*; a lower vegetation height, a shorter distance to the stream, and a lower percentage cover of *Scirpus* sp. and *Spartina* spp. than the unused sites (Table 1(a), Fig. 2). In autumn–winter, used sites showed greater cover of *Plantago lanceolata*, *Trifolium repens*, *Lolium multiflorum* and *Stipa* spp.; lower vegetation height, lower distance to the stream and lower percentage cover of *Distichlis* spp. and *Spartina* spp. than the unused sites (Table 1(b)). In spring, used sites were characterized by a greater cover of *Phyla canescens*, *Lolium multiflorum*, *Mentha pulegium*, a greater proximity to the stream, a lower percentage of bare soil, and a lower cover of *Scirpus* sp. and *Distichlis* spp. than the unused sites (Table 1(c)).

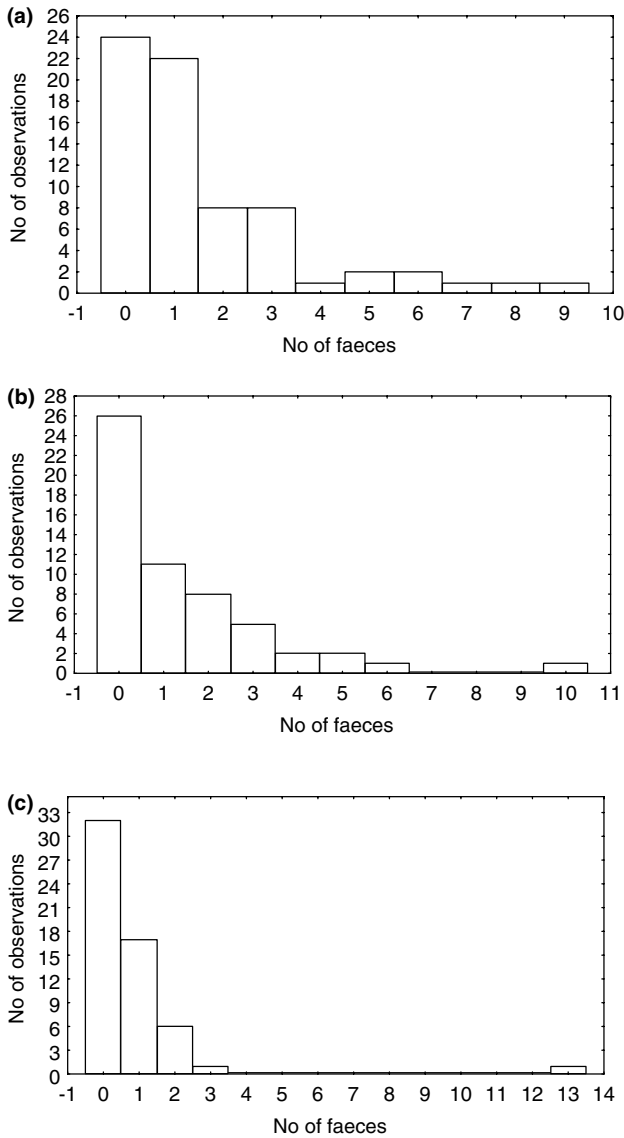


Fig. 1. Frequency distribution of the number of faeces observed in summer (a), autumn–winter (b) and spring (c).

Table 1
Pearson correlation coefficients (*R*) calculated between the first discriminant variable (DV1) and the original variables

Variable	DV1
<i>(a) Summer</i>	
Vegetation height	0.55*
Distance to stream	0.53*
<i>Scirpus</i> sp.	0.42*
<i>Spartina</i> spp.	0.25*
<i>Eryngium nudicaule</i>	0.22
<i>Lolium multiflorum</i>	0.07
<i>Bupleurum</i> sp.	0.07
Bare soil	−0.03
<i>Distichlis</i> spp.	−0.03
<i>Thinopyrum ponticum</i>	−0.05
Distance to fences	−0.06
<i>Trifolium repens</i>	−0.09
Distance to route	−0.12

Table 1 (continued)

Variable	DV1
<i>Mentha pulegium</i>	−0.15
<i>Chaetotropis elongata</i>	−0.16
Distance to house	−0.20
<i>Plantago lanceolata</i>	−0.26*
<i>Sida leprosa</i>	−0.31*
<i>Phyla canescens</i>	−0.31*
<i>Stenotaphrum secundatum</i>	−0.55*
<i>(b) Autumn–winter</i>	
Vegetation height	0.60*
Distance to stream	0.54*
<i>Distichlis</i> spp.	0.42*
<i>Spartina</i> spp.	0.39*
<i>Hordeum pusillum</i>	0.13
Bare soil	0.12
<i>Thinopyrum ponticum</i>	0.03
<i>Bothriochloa laguroides</i>	0.03
Distance to route	−0.04
<i>Bromus</i> sp.	−0.06
Distance to house	−0.06
Distance to fences	−0.07
<i>Phyla canescens</i>	−0.14
<i>Solanum malacoxylon</i>	−0.17
<i>Chaetotropis elongata</i>	−0.22
<i>Stenotaphrum secundatum</i>	−0.22
<i>Stipa</i> spp.	−0.28*
<i>Lolium multiflorum</i>	−0.48*
<i>Trifolium repens</i>	−0.56*
<i>Plantago lanceolata</i>	−0.58*
<i>(c) Spring</i>	
Distance to stream	0.40*
Bare soil	0.40*
<i>Scirpus</i> sp.	0.35*
<i>Distichlis</i> spp.	0.26*
<i>Spartina</i> spp.	0.22
<i>Salicornia ambigua</i>	0.21
Vegetation height	0.14
<i>Lagurus</i> sp.	0.14
<i>Paspalum dilatatum</i>	0.04
Distance to house	−0.03
Distance to fences	−0.05
<i>Thinopyrum ponticum</i>	−0.08
<i>Trifolium repens</i>	−0.10
<i>Chaetotropis elongata</i>	−0.11
Distance to route	−0.13
<i>Stenotaphrum secundatum</i>	−0.34*
<i>Plantago lanceolata</i>	−0.37*
<i>Bupleurum</i> spp.	−0.39*
<i>Stipa</i> spp.	−0.41*
<i>Mentha pulegium</i>	−0.41*
<i>Lolium multiflorum</i>	−0.49*
<i>Phyla canescens</i>	−0.51*

Discriminant variables resulted from a discriminant analysis performed on summer (a), autumn–winter (b) and spring (c) data. The species with a significant *R* value for *p* < 0.05 are indicated with “*”.

3.2. Modeling habitat use

The confidence intervals for canonical scores of each group of faeces partly overlapped, but eight of the 10 control points were correctly classified into their corresponding intervals and two points were classified into

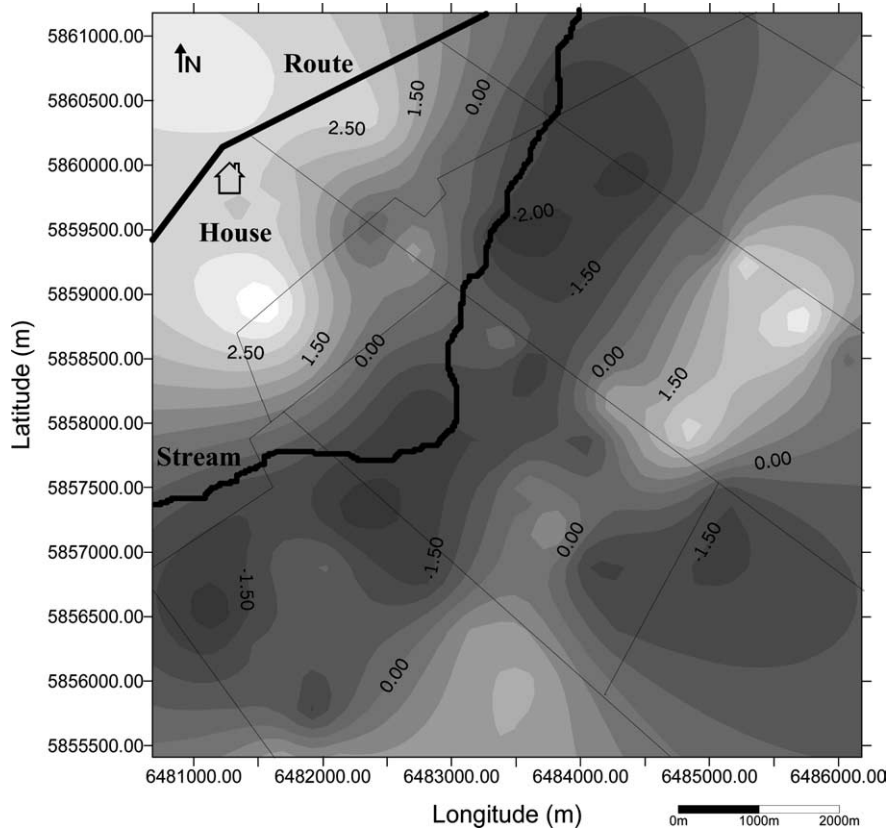


Fig. 2. *Rhea americana* habitat use in summer 1999 (Ea. Medaland, Buenos Aires Province). Levels of grey intensity represent a discriminant variable of faeces presence on the basis of floristic composition and landscape attributes. Darker locations represent the most used areas by rheas, while lighter ones are the less used. Numbers indicate some values of the discriminant variable.

Table 2

Confidence intervals (95%) for canonical scores around the mean of each group of faeces and the constructed canonical scores for each eliminated sample (CSES)

Means of canonical scores	CI (95%)	CSES
G1: 1.780	(-0.60; 4.24)	-0.35; 1.084; 2.09
G2: -1.029	(-2.87; 0.75)	-1.98; -1.91; -1.63; -1.58; -1.41; -1.23; 0.24

G1, group without faeces; G2, group with faeces.

the overlapping region (Table 2). It is worth noting that this result does not contradict the significant results of the discriminant analysis. The intervals constructed for the validation of the model took into account the standard deviation of the score values around the mean, while the statistical test for analyzing the significance of the discriminant variable was based on the standard error of the mean.

4. Discussion

At the present, rheas are threatened by man, indirectly due to the alteration of their natural habitats and

directly by hunting. Accordingly, it might be expected that habitat use by rheas would be mainly explained by anthropogenic variables. However, those variables related with human activity such as the presence of a route, house and fences, have shown a low predictive value on the habitat use by rheas when compared with resource variables of this agroecosystem at the scale we were working.

Rheas preferentially selected the stream area in all seasons. In this environment rheas were not alone, but associated with cows and sheep (pers. obs.). The association of rheas with these animals is probably an indirect effect of similarity in habitat selection, but it can be advantageous for both in another sense, since the combination of the former's good eyesight with the latter's excellent scent increases their efficiency in detecting enemies at a distance (Folch, 1992). Besides offering water to drink, the quality of forage for rheas could be better near the stream than far away from it. On the edges of the stream, riparian communities dominated by dicot species are established, as these species colonize disturbed areas generated by flow fluctuation and animal stamping. Habitats with a great proportion of dicots were found optimal as feeding sites for rheas (Demaría, 1993). Moreover, in a study of the composition of the

diet of rheas in the same establishment of the present research, Comparatore et al. (2001), found that in spring, when vegetation availability is high, rheas selected dicots and rejected monocots. Places far from the stream such as those dominated by *Spartina* spp. (espartillar), *Scirpus* spp. (juncal) and *Distichlis* spp. (pradera salada) seem to be less used by rheas, according to the low frequency of faeces found there. However, and contrary to the results presented here, in summer and spring rheas were seen walking at the edge of the “espartillar” and nests were found in its interior (pers. obs.), suggesting that during the reproductive period other vegetation variables such as shelter for nesting could be affecting habitat selection.

Vegetation height was another important variable in discriminating samples with faeces. In summer and autumn–winter, tall canopy was a characteristic of unused sites. Rheas would avoid plant communities with tall canopies because they would not allow them to see the surroundings and the presence of predators; these results are consistent with those obtained by Martella and Demaría (1993). These authors studied the habitat use by rheas during the non-reproductive period. Habitat use by rheas depends on vegetation physiognomy, as reflected by their preference for open rather than forested habitats (Mercolli, 1993), and for areas with vegetation height lower than 50 cm and undisturbed by humans (Martella and Demaría, 1993). These authors suggested that this species selects habitat according to trade-offs among resource availability, risk of predation and human perturbation. Jory (1975) observed that lesser rheas raised their heads more often to look around in areas with bad visibility (valleys covered with shrubs) than in those with good visibility (grasslands). This result indicates that there may be a relationship between vigilance and risk of predation.

Used sites were characterized by a greater percentage of species such as *Bupleurum* sp. *Phyla canescens*, *Sida leprosa*, *Plantago lanceolata* and *Trifolium repens*, among the dicots, and *Lolium multiflorum*, *Stipa* spp., and *Stenotaphrum secundatum*, among the grasses. These species could be important components of rhea's diet. Yagueddú and Viviani Rossi (1985) carried out a study of rhea's diet in a natural grassland of Buenos Aires Province, and found that in summer, dicots were the principal components of diets, *Phyla canescens* and *Plantago lanceolata* being the most consumed.

Contrary to what expected, distance to route, house and fences did not show any important contribution to discriminant variables obtained for the three seasons, so its presence would not represent an important landscape element affecting habitat use by rheas at this study site. Indeed, rheas have no problem passing through the standard seven wire cattle fences normally used in Argentina.

In relation to the decomposition of faeces in the study area, the results obtained are consistent with those ob-

tained by Camezzana (1987). This author studied the diet of the lesser rhea, *Pterocnemia pennata*, in an establishment in Chubut Province in the Patagonian steppe (Argentina). He proved that in a period of three months, faeces were disaggregated and incorporated to the soil. This result with those obtained in this study indicate that fresh faeces registered during our study were dropped during the sampled season. Therefore, the faecal-pellet count method resulted a suitable tool for rhea's habitat use studies.

Mapping allowed a visual analysis of the most frequented areas by rheas. It is a very important tool that should permit the management of rhea populations by the application of predictive models. The very good feasibility of habitat use validation presented here suggests that the generated model is optimal for the management of rhea populations on other cattle ranches of the region and to analyze the suitability of other ranches for reintroduction programs.

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