<table>
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<tr>
<th>Method</th>
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<tr>
<td>PZP</td>
<td>ZonaStat-H</td>
<td>numerous studies (especially Assateague Isl.; used in the field; EPA registered)</td>
<td>4 injections given in 2-4 week intervals + 6-10 months after last injection (n=10) resulted in 10-20% pregnancy rates</td>
<td>minimum of 2 inoculations is required in horses in order to raise sufficiently high antibody titers for a minimum of 6 months; horses may become difficult to access after numerous treatments</td>
<td>Liu et al. (1989) J Reprod Fertil 85:19-28</td>
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<td>2 injections (n=8) resulted in pregnancy rates of 12%; 3 injections (n=18) resulted in pregnancy rates of 0% compared to 45% for untreated mares (n=11)</td>
<td>booster doses result in a more robust immune response</td>
<td>Kirkpatrick et al. (1990) Wildl Soc Bull 18:326-330</td>
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<td>3 years of consecutive treatments (n=10) is &gt;90% effective in preventing pregnancy compared to a 55% pregnancy rate in untreated mares (n=20)</td>
<td>prolonged treatment may interfere with ovarian function (based on depressed estrogen secretion)</td>
<td>Kirkpatrick et al. (1992) J Reprod Fertil 94:437-444</td>
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<td>treatment for 1-2 years (n=11), &gt;3 years (n=19), or no treatment (n=42) resulted in significant (p&lt;0.05) differences in longevity, with contraceted mares living longer</td>
<td>treated mares are healthier &amp; live longer because they don’t have to give birth &amp; lactate; a consideration for population modeling</td>
<td>Kirkpatrick et al. (2007) Zoo Bio 26:237-244</td>
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<td>SpayVac</td>
<td>3 studies completed; EPA registration underway</td>
<td>single injection (n=12) resulted in pregnancy rates of 0, 17, 17 &amp; 17% compared to 75, 75, 88 &amp; 100% for controls (n=8) 1-4 years post-vaccination, respectively</td>
<td>initial trial with promising results for single injection (no boosters); study ended after year 4</td>
<td>Killian et al. (2008) Wildl Res 35:103-115</td>
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<td>3-4 months post-single injection (n=14) 93% of mares stopped cycling based on lower serum progesterone (p&lt;0.025) &amp; smaller ovaries (p&lt;0.001) compared to controls (n=7)</td>
<td>originally designed as a safety trial requested by BLM; demonstrated that pZP may act in different ways (not just antibody-binding) - confirmed by Joone et al. (2017) Equine Vet J 49:189-195 in pony mares using ZonaStat</td>
<td>Bechert et al. (2013) Wildl Manage 77:1386-1400</td>
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<td>single injection (n=30) resulted in foaling rates of 13, 47 &amp; 43% compared to 100, 88 &amp; 100% in controls 1-3 years post-vaccination, respectively (SpayVac VaccinMax formulation)</td>
<td>vaccinations were given in rump, unlike Killian et al. (2008) &amp; Bechert et al. (2013) studies, which administered vaccines in the neck closer to major lymph nodes</td>
<td>Roelle et al. (2017) Wildl Soc Bull 41:107-115 Bechert &amp; Fraker (2018) Human-Wildl Interact 12:117-130</td>
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<td>IgG1 antibodies higher in infertile treated mares, especially IgG4/7 (p&lt;0.05), compared to fertile treated mares from Roelle study</td>
<td>IgG4/7 provides long-lasting immunity compared to other IgG isotypes</td>
<td>Bechert et al. (2018) Theriogenology 121:168-174</td>
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<td>PZP-22</td>
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<td>3 studies completed</td>
<td>injections of pZP + PLGA copolymer pellets generated antibody titers similar to ZonaStat + booster at 3-4 weeks; titers remained elevated for almost 11 months</td>
<td>pellets eliminated the need for a booster 3-4 weeks after initial vaccination with ZonaStat</td>
<td>Liu et al. (2005) Reproduction 129:181-190</td>
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<td>injections of pZP + QS-21 pellets (n=96) resulted in fertility rates of 6, 14, 32, and 48% for 1-4 years post-injection, respectively compared to 54% for untreated mares</td>
<td>contraceptive efficacy was effective for two breeding seasons (22 months post-injection)</td>
<td>Turner et al. (2007) J Wildl Manage 71:662-667</td>
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<td>remote dart injection of 100 µg pZP vaccine + 450 µg pZP in QA pellet resulted in foaling rates of 12 &amp; 35% (n=17) compared to 56 &amp; 54% in untreated mares (n=27, 26); significant for 1st year</td>
<td>remote delivery is effective for 1 year</td>
<td>Carey et al. (2019) Wildl Res 46:713-718</td>
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<td>GnRH</td>
<td>SionaCon</td>
<td>3 studies completed; EPA registration</td>
<td>single injection with 1800 µg GnRH (n=11) or 2800 µg GnRH (n=4) resulted in pregnancy rates of 7, 36, 43, and 57% compared to 75, 75, 88 &amp; 100% for controls (n=8) 1-3 years post-vaccination, respectively</td>
<td>AdjuVac was the adjuvant (same as for the SpayVac used in this study); GnRH is smaller than pZP so it may be harder to elicit an immune response</td>
<td>Killian et al. (2008) Wildl Res 35:103-115</td>
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<td>single injection (n=29) resulted in foaling rates of 64% and 69% compared to controls during 2 and 3 years post-vax, respectively</td>
<td>boosters have a very positive impact on vaccine efficacy</td>
<td>Baker et al. (2017) Proc 8th Intl Conf Wildl Fertil Control</td>
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<td>single injection (n=26 to 28) resulted in foaling rates of 46, 56 and 69% compared to 73, 78 &amp; 67% for controls (n=26 to 27) during 2-4 years post-vaccination, respectively -- a booster 4 years later (n=25) resulted in foaling rates of 0 and 16% compared to 84% for controls 1-2 years post-vaccination, respectively</td>
<td>boosters have a very positive impact on vaccine efficacy</td>
<td>Baker et al. (2018) PLOS One 13(7): e0201570</td>
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<td><strong>FERTILITY CONTROL TOOLBOX</strong></td>
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<td><strong>BMP-15 &amp; GDF-9</strong></td>
<td>n/a</td>
<td>1 study completed &amp; 1 underway; experimental</td>
<td>Vaccination with either GDF-9 or BMP-15 + boosters at 6, 12 and 18 weeks had no effect on ovulation for GDF-9 (n=10) but was less (p=0.02) for BMP-15 (n=10)</td>
<td>GDF-9 decreased average follicle size &amp; altered estrous behavior; BMP-15 decreased average follicle size, altered estrous behavior &amp; decreased number of ovulations</td>
<td>Davis et al. (2018) Ani Reprod Sci 192:69-77</td>
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<td>Results will demonstrate actual contraceptive efficacy</td>
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<td><strong>Hormone Implants</strong></td>
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<td>Estradiol and/or progesterone in silastic rods</td>
<td>n/a</td>
<td>experimental</td>
<td>Silastic rods containing ethynylestradiol, estradiol-17β, or progesterone were implanted into feral mares ranging from 4-10 years old; fertility rates were 12-22%; mares that were pregnant when treated carried their pregnancies to term</td>
<td>Implanting silastic rods is more invasive than simple inoculations; there is some, albeit limited, potential that the hormones could enter the food chain if treated mares are killed and eaten by predators and scavengers</td>
<td>Plotka et al. (1992) J Wildl Dis 28:255-262 Eagle et al. (1992) Wildl Soc Bull 20:211-216</td>
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<td><strong>Testosterone propionate</strong></td>
<td>n/a</td>
<td>experimental</td>
<td>Foul counts for control bands averaged 0.373 foals per mare, whereas for treated bands (n=10) the average was 0.066</td>
<td>Must be hand-injected because of viscosity, which requires immobilization of stallions</td>
<td>Kirkpatrick et al. (1982) J Equine Vet Sci 24(6):114-118</td>
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<td><strong>Surgical</strong></td>
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<td>Ovariectomy</td>
<td>n/a</td>
<td>used experimentally and once in the field</td>
<td>Ovariectomized by colpotomy (n=102) in 2010-11; 8 died pre-release; release occurred 3-8 days post-procedure; aerial surveys done post-release</td>
<td>Mares &amp; stallions were treated over an 8-year time period with removals conducted at the same time, making it difficult to evaluate specific treatment effects</td>
<td>Collins &amp; Kasbohm (2017) J Wildl Manage 81(2):289-296</td>
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<td>Castration</td>
<td>n/a</td>
<td>used with domestic horses</td>
<td>Vasectomized (n=137), chemically epididymectomized (n=126), castrated (n=5); aerial surveys done post-release</td>
<td>Peak foaling rates for Sheldon (study site) were 11.4, 5.4, 5.4 (avg 7.4) compared to Massacre Lake HMA 13.0, 3.3, 6.5 (avg 7.6) for 2010, 2011, 2014</td>
<td>(Same study)</td>
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<td><strong>Physical</strong></td>
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<td>IUD</td>
<td>n/a</td>
<td>used experimentally</td>
<td>Silastic O-ring-shaped IUDs (n=6) resulted in pregnancy rate of 0% compared to 100% for controls (n=12) for 1 year; IUD fell out of 1 treated mare prior to removal in year 2</td>
<td>Contraceptive efficacy only tested for 1 year</td>
<td>Daels and Hughes. (1995) Theriogenology 44:629-639</td>
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<td>n/a</td>
<td>used experimentally</td>
<td>Copper T IUDs (n=15) resulted in pregnancy rates of 20, 71, 86 and 100% compared to 75, 75, 88 and 100% for controls for year 1-4 post-treatment, respectively</td>
<td>Contraceptive efficacy only lasted 1 year</td>
<td>Killian et al. (2008) Wild Res 35:103-115</td>
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<td>LUPOD</td>
<td>2 studies completed</td>
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<td>Self-assembling magnets form a triangle in the uterus; retention length was up to 5 months; requires that mares are not pregnant</td>
<td>Contraceptive efficacy not tested</td>
<td>Gradi et al. 2019</td>
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<td>0% of the treated mares became pregnant over a 3 month (n=4) or 4 month (n=4) period; 5 of 8 mares had intra-uterine fluid build-up, but improved with estrus &amp; ovulation and none of the mares had fluid build-up at the completion of the study; reversibility was observed within 30 days post-device retrieval</td>
<td>Mares cycle but also experience prolonged diestrus; contraceptive efficacy was 100% for 3-4 months</td>
<td>Gradi et al. (submitted)</td>
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