PRIMUS: Rapid Reconstruction of Pedigrees

from Genome-Wide Estimates of Identity by Descent

Jeffrey Staples, Dandi Qiao, Michael H. Cho, Edwin K. Silverman, University of Washington Center for Mendelian Genomics, Deborah A. Nickerson, and Jennifer E. Below
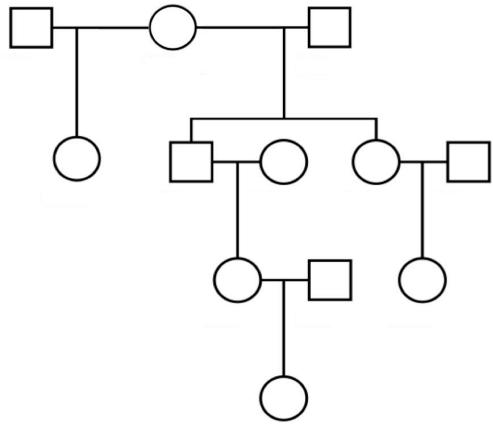
Figure S1. Schematic of a simulated 12-person pedigree. This pedigree contains all types of familial relationships shown in Table 1. We randomly assigned HapMap3 CEU haplotypes to each of the founders and then simulated recombination events to propagate these genotypes to the children.
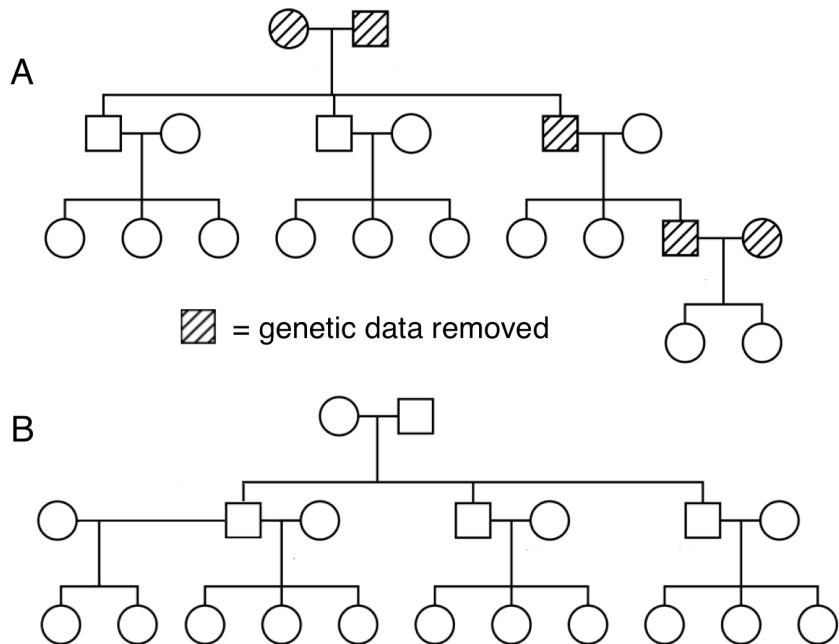
Figure S2. Examples of simulated pedigrees of size 20. A) Uniform size-20 pedigree with five samples for whom the genetic data was removed. The missing individuals simulated the real world case where you cannot get good genotypes from an individual either due to lack of consent, poor DNA quality, contamination, or absence of the individual. All of the remaining individuals are genotyped and are included in the pedigree and the reconstruction. B) Halfsib size-20 pedigree without any missing individuals.
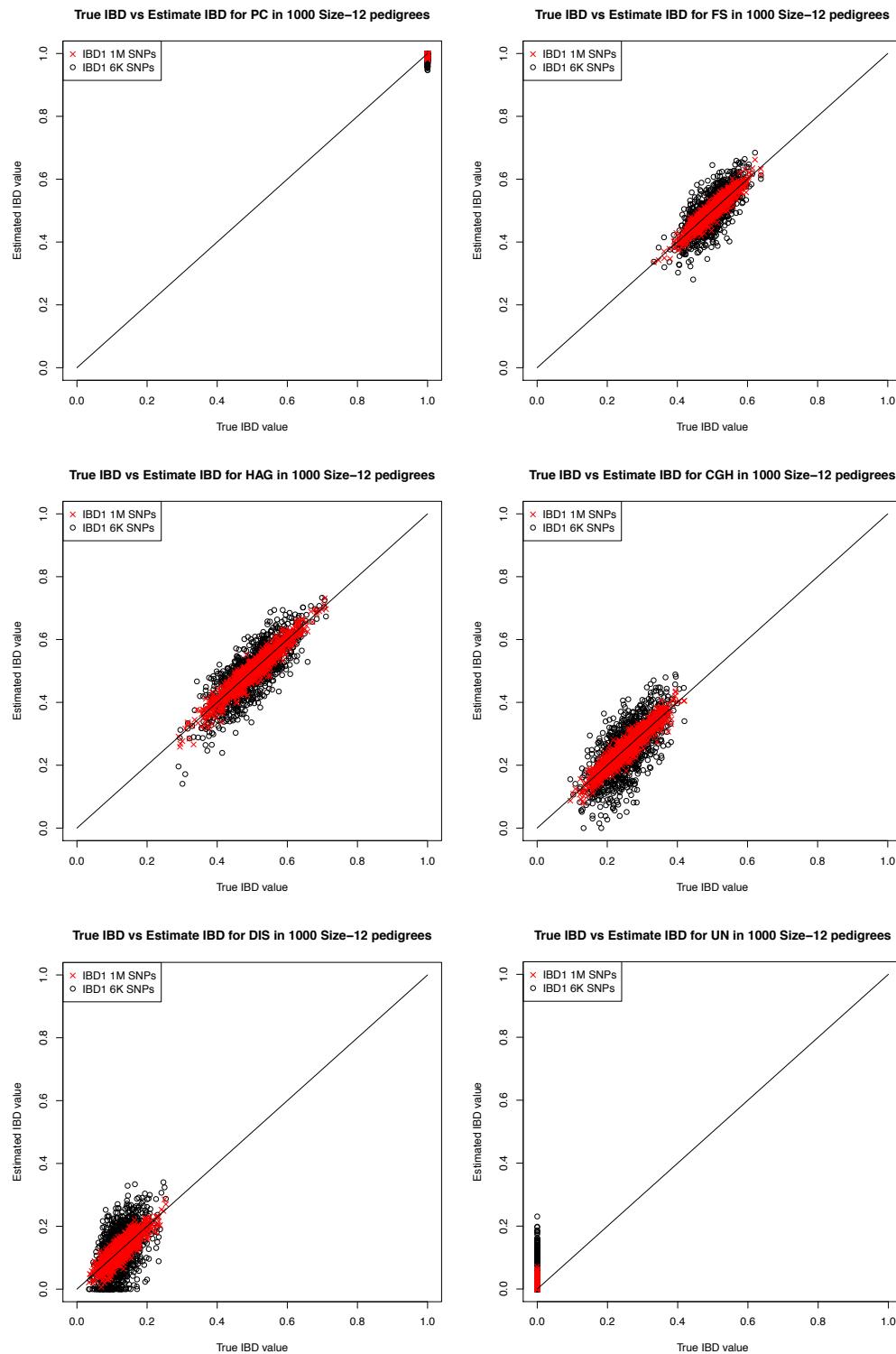
Figure S3. Comparison of the true IBD1 value to the PLINK IBD1 estimates for relationship sampled from 1000 size-12 pedigrees. Each graph shows the comparison of 6K SNPs and 1 million SNPs to the true IBD value. Each plot shows a different relationship category. IBD estimates generated from 6K SNPs have a much wider variance than the one IBD estimates generated from 1M SNPs. However, the distance that they depart from the expected value appears to remain fairly constant at each degree of relatedness.
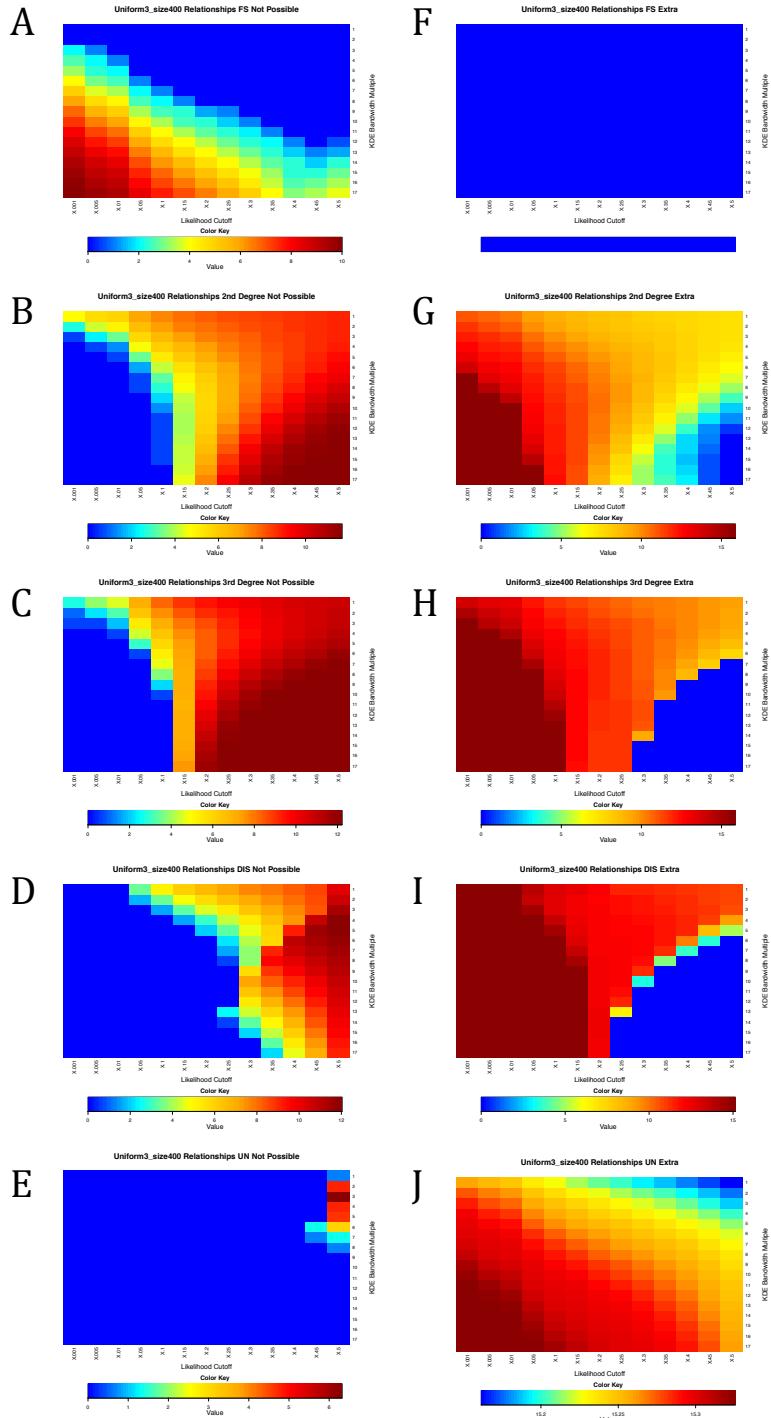
Figure S4. False positive (FP) and false negative (FN) relationship predictions with different KDE bandwidths and likelihood cutoffs for full-sibling (FS), 2nd degree, 3rd degree, distant (DIS) and unrelated (UN) relationships. We used these predictions to optimize the ability of PRIMUS to accurately identify the relationship between two individuals (true positive = 1 - FN) while minimizing the number of incorrect relationships that it predicts (FP). Since the optimal bandwidth would need to perform well across different likelihood cutoffs, we tested the performance of PRIMUS with likelihood cutoffs ranging from 0.01 to 0.5. We used the scipy.stats.gaussian_kde function (Web Resources) with two training features: genome-wide estimates of IBD0 and IBD1. We tested a range of bandwidths by specifying scalar values 1 through 17 as the "bw_method" option and these values are used as the

coefficient that multiplies the data covariance matrix to obtain the kernel covariance matrix. With KDEs trained at each bandwidth coefficient value from 1 to 17, we predicted the relationship category of each relationship in the 100 Uniform size-400 pedigrees at likelihood cutoffs varying from 0.01 to 0.5. We evaluated the relationship prediction of the KDEs trained with different bandwidths by testing their FN (results A-E) and FP (results F-J) rates. The color in each cell indicates the number of relationships from the 100 size-400 Uniform pedigrees that were either FN or FP. The color scale is $\log_{10}$. An FN occurs if the true relationship did not have a likelihood higher than the cutoff. An FP occurs if a relationship other than the true relationship has a likelihood higher than the likelihood cutoff. Parent-offspring relationships did not have any FP or FN predictions, so the corresponding heat maps are not shown. We selected the covariance factor for each relationship category that minimized the FP and FN predictions, and these are set as the default in PRIMUS: PO = 17; FS = 2; 2nd degree = 6; 3rd degree=5; DIS = 2; UN = 1. With an initial likelihood threshold higher than 0.3, we found a higher rate of false negative relationship predictions for 2nd degree, 3rd degree, and distantly related relationships in the Uniform size-400 pedigrees (Figure S3). However, lowering this threshold results in more relationships with likelihood scores that exceed the threshold. If there is more than one relationship category that exceeds the likelihood threshold, then PRIMUS will attempt to reconstruct a different version of the pedigree for each possible relationship, resulting in additional computational time. Therefore, we desired a default threshold that was lenient enough to reduce the chance of a false negative prediction, but also stringent enough to minimize the number of false positive relationships that are tested in the reconstruction. We chose 0.01 as the lower likelihood threshold bound because all relationship categories had 0% false negative rate at this threshold for their selected bandwidth. The strategy for the automatically lowering threshold is designed to capture the true pedigree while minimizing the runtime and the number of possible false positive pedigrees. This strategy assumes that PRIMUS will not output a pedigree structure until all true relationships have a likelihood higher than the likelihood threshold, and, thus, it will be able to reconstruct the true pedigree structure. There are rare scenarios (~0.5% of the simulations, Table S2) where PRIMUS did not output a correct pedigree structure before the threshold was low enough to correctly predict all familial relationships. Therefore, in this rare scenario, the true pedigree structure was not among the PRIMUS results. In these instances, PRIMUS can generate the true pedigree structure if the likelihood threshold is initially set low enough (e.g., 0.01). We chose 0.3 as the default because it provides the greatest savings in runtime and reduced number of possible pedigrees for the common uses of PRIMUS, but users can select a different value to fit their custom needs.
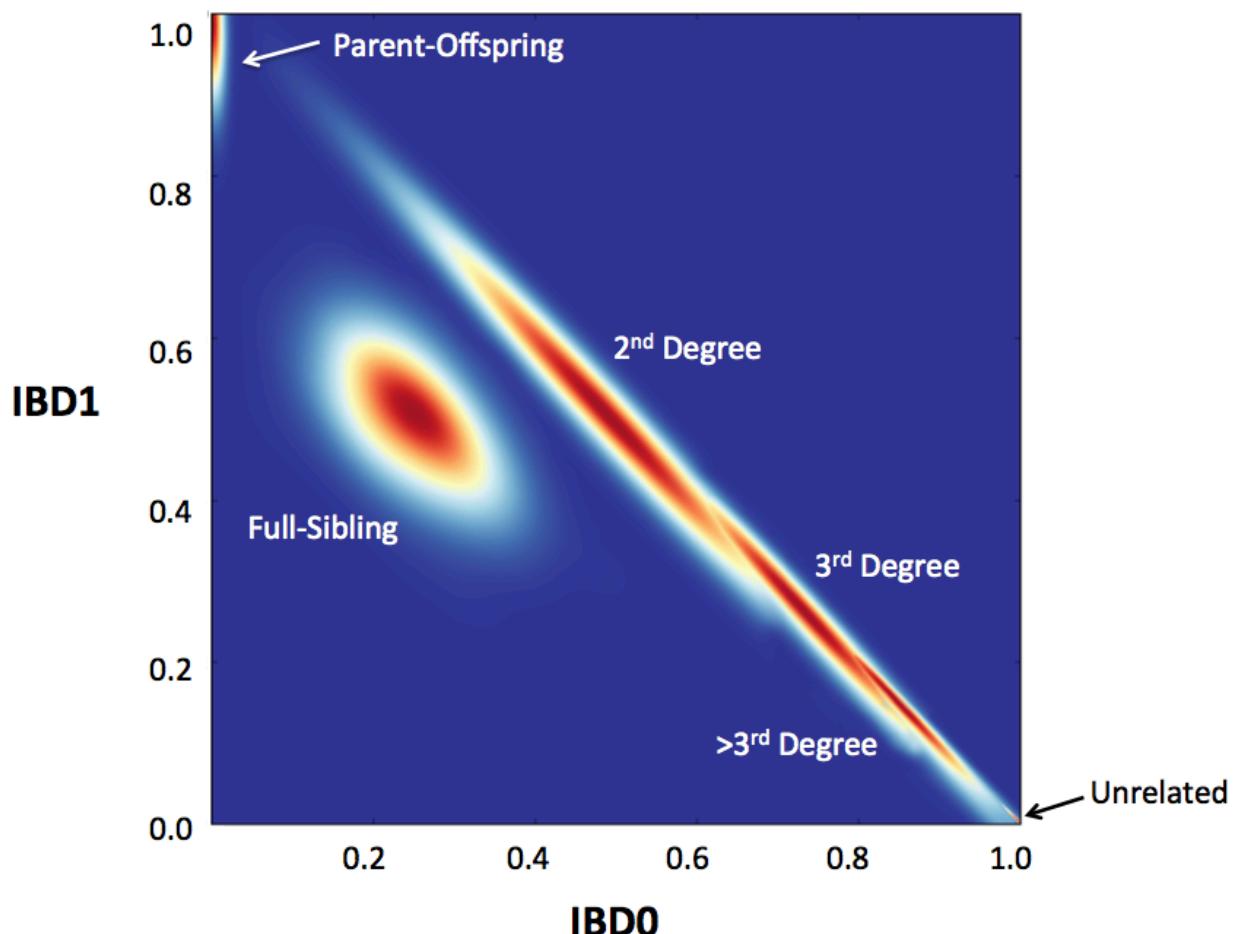
Figure S5. Kernel density distributions of the trained kernel density estimates for each familial relationship category. Parent-offspring and full-sibling are viably separated from the other density clusters. 2nd Degree and 3rd Degree are labeling the distribution of IBD estimates for 2nd and 3rd degree relationships, respectively. >3rd degree and "Unrelated" label the distributions of IBD estimates for relatives more distant that 3rd degree or unrelated, respectively.
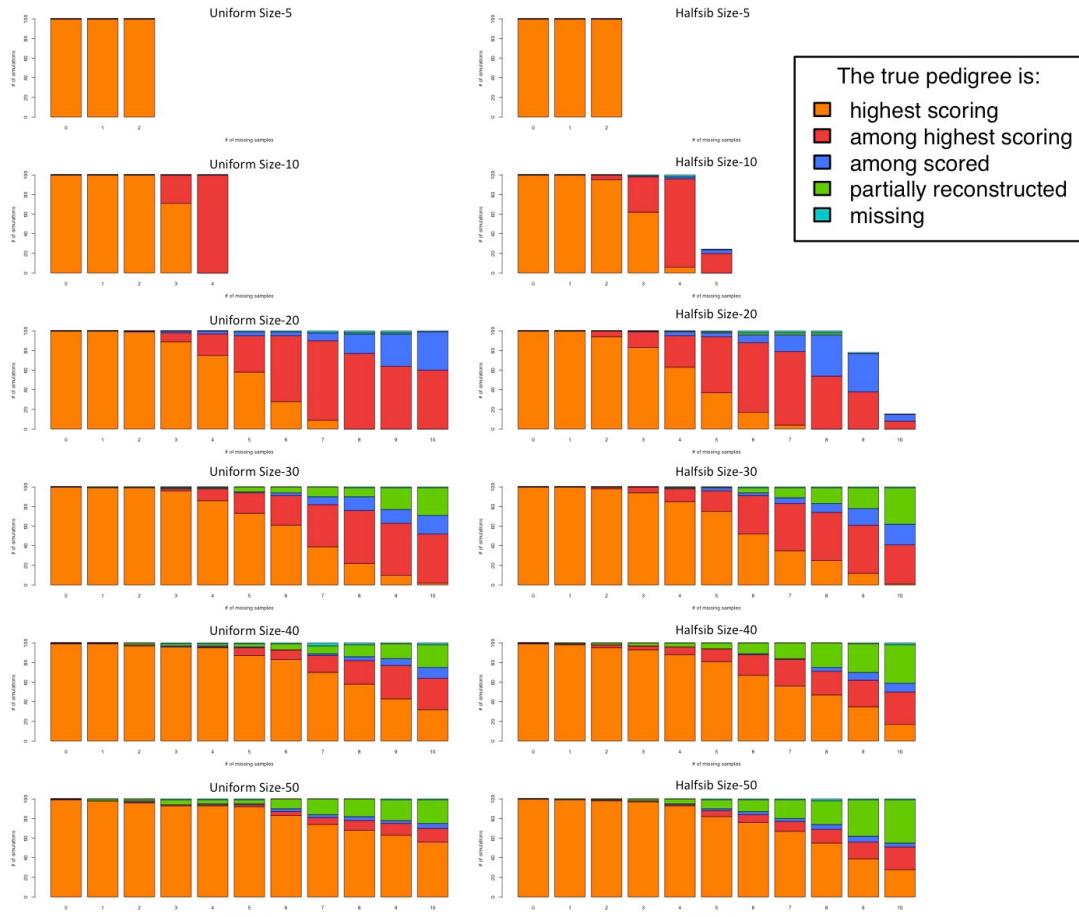
Figure S6. Results from the reconstruction of simulated pedigrees. We simulated 100 pedigrees for each size from five to 50 and for both Uniform and Halfsib pedigree structures. We removed up to ten samples from each pedigree and reconstructed each in PRIMUS. For each simulation we determined where the true pedigree fell among the ranked reconstruction results. Each bar displays the proportion of the 100 simulations that corresponded to the five reconstruction outcomes. Some of the Halfsib pedigree structures allowed for more samples to be removed than others due to the random nature of how they were simulated. As a result, Halfsib size-10 with five missing samples and size-20 with nine and ten missing samples do not have 100 unique simulations. The different outcomes are defined as follows:

"highest scoring" – The true pedigree is the highest scoring pedigree

"among highest scoring" – PRIMUS output contained more than one possible pedigree, and the true pedigree is tied as the highest scoring pedigree with one or more other pedigrees

"among scored" – the true pedigree is not the highest scoring pedigree, but is among the pedigrees generated by PRIMUS

"partial reconstruction" – the complete reconstruction either resulted in too many possible pedigrees, ran out of memory, or took longer than 36 hours to run, and, as a result, only a partial reconstruction using 1st degree relationships was generated

"missing" – PRIMUS reconstructed one or more possible pedigrees, but the true pedigree was not among them

Figure S7. Simulation runtime results. These simulations were run on a single Intel Xeon CPU X5690 @ 3.47GHz with up to 35GB of RAM.
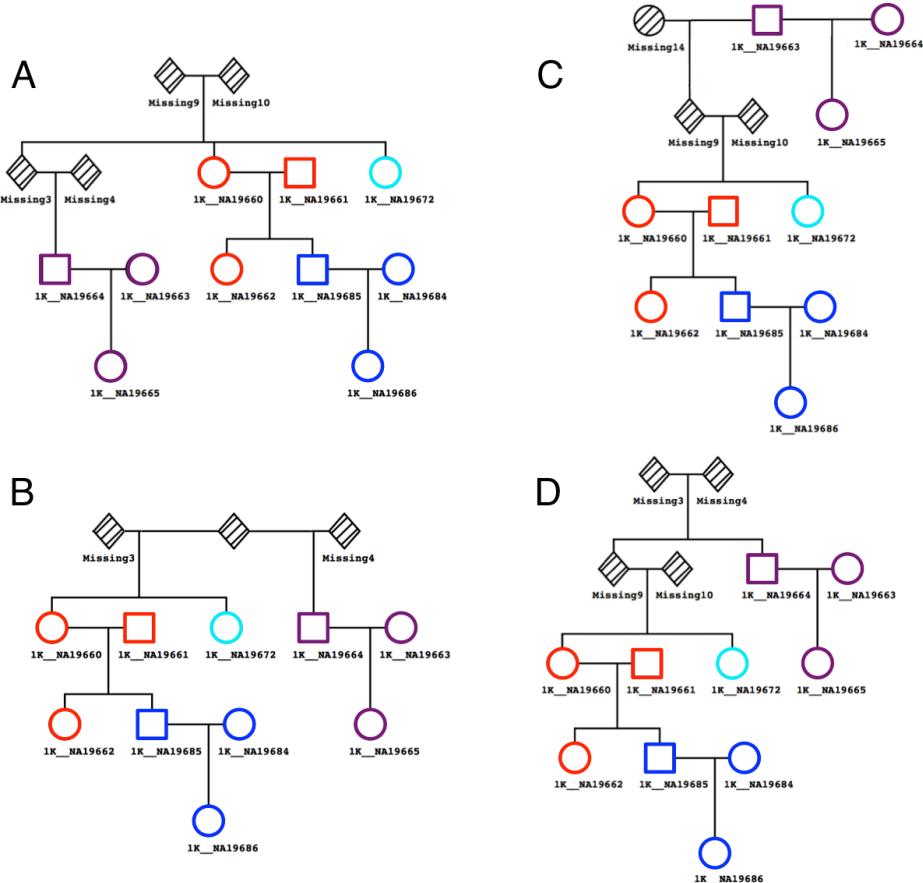
Figure S8. A ten-person MapMap3 MXL pedigree obtained from the HapMap3 and 1000 Genomes samples. The pedigree includes three reported trios (each colored differently) from HapMap3 and an additional individual from the 1000 Genomes Project. The pedigree shown in A is one of four possible pedigrees that fit the estimated IBD proportions and is the pedigree previously reported[1]. Alternative possible pedigrees that fit the genetic data are shown in B, C, and D. For these MXL samples, PREPARE reported a single sibling relationship (NA19662, NA19685), the two first-cousin relationships (NA19662-NA19664 and NA19664-NA19685). PREPARE is presented to have automatically reconstructed the nine-person HapMap3 MXL pedigree reported in the CARROT paper[1], but they only show that NA19686 (incorrectly labeled as NA19685 in Figure 14 of their paper[2]) and NA19665 are 2nd cousins. Unlike the PRIMUS automatic reconstruction (Figure S8), they do not show how the other eight individuals fit into the pedigree, nor do they acknowledge that there are four different pedigree structures that fit the genetic data.
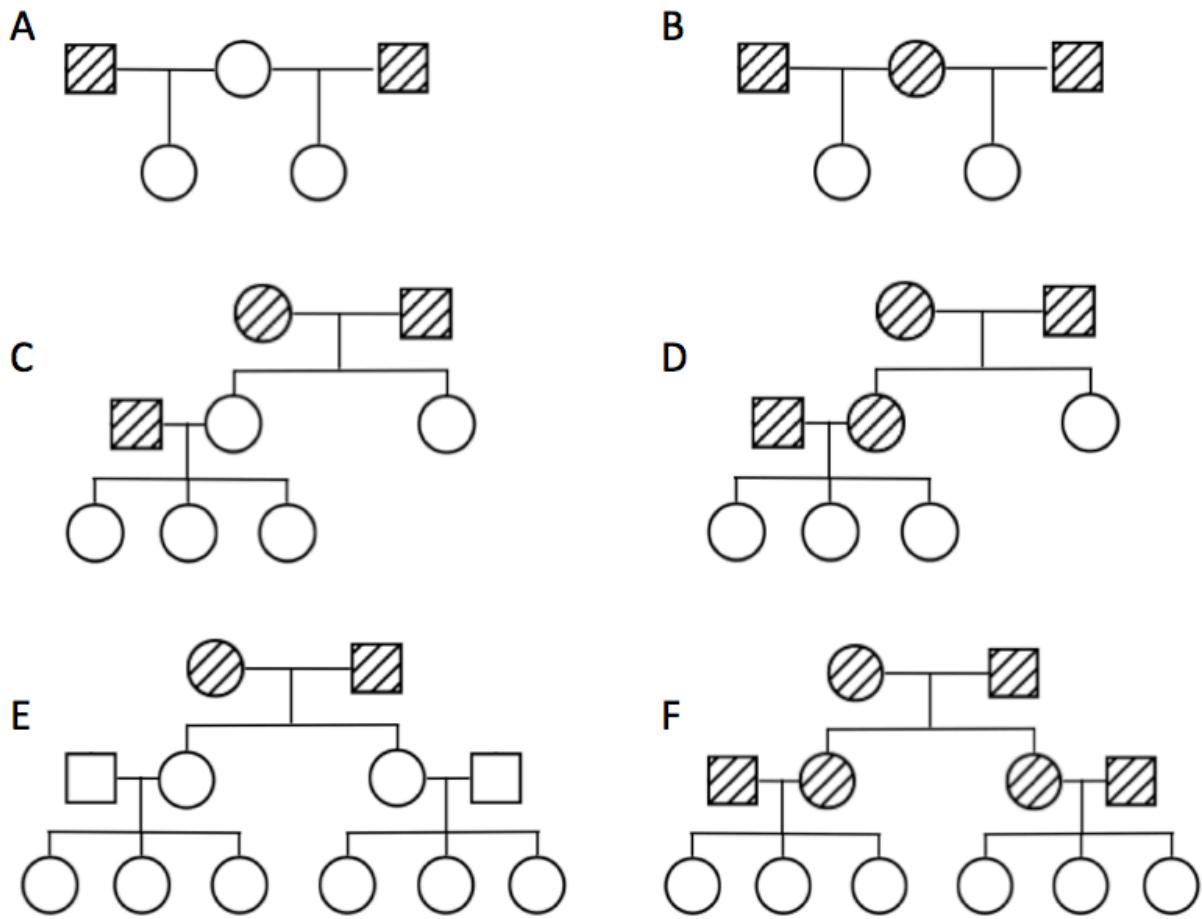
Figure S9. Examples of simple and common pedigrees structures. Diagonal lines through an individual's symbol indicate that DNA data are unavailable for that individual. PRIMUS can easily reconstruct all six pedigree structures. PREPARE[2] and IPED2 (He *et al.*, in press) can reconstruct pedigrees B and F because they require that all genotyped samples be in the same generation. If we had prior knowledge of each of these pedigrees, ages of the samples, or knowledge of who was in which generation, then PREPARE and IPED2 could do partial reconstructions of the lowest generation of each pedigree and the middle generation of C by discarding the other genotyped individuals. IPED[3] and COP/CIP[4] can only reconstruct pedigree F, because they are unable to handle half-sibling relationships, but could do the same partial reconstruction of the same pedigrees as PREPARE and IPED, except for A.
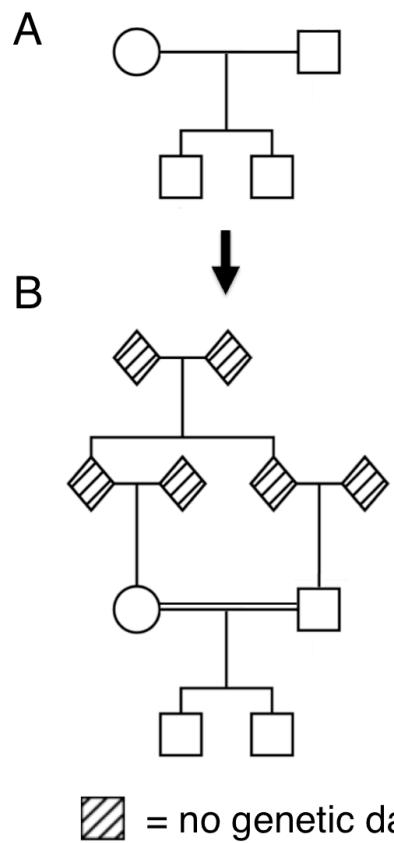
Figure S10. A pedigree submitted to the UW Center for Mendelian Genomics. The parents were reported as unrelated individuals by the clinician as depicted in pedigree A, but PRIMUS reconstructed them as first cousins, as depicted in pedigree B.
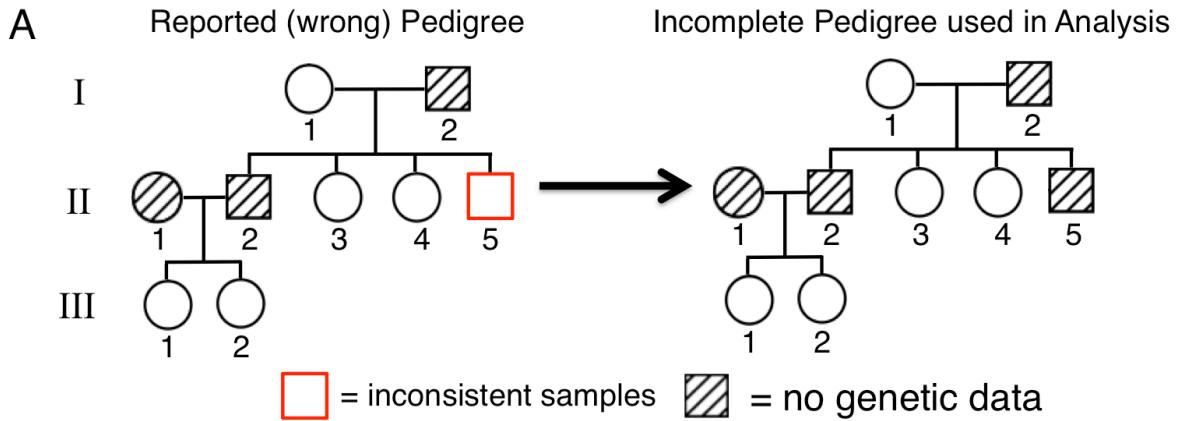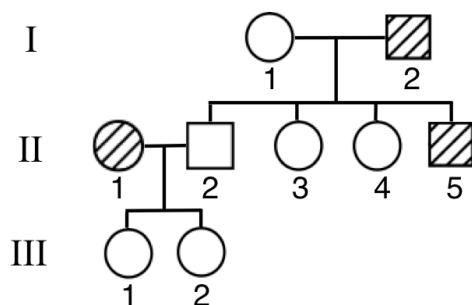
Figure S11. A single example where pairwise relationship checking and removal of an inconsistent sample results in an unnecessary loss of data. Panel A shows the reported pedigree as provided by the investigator. Pairwise relationship checking reveals that all relationships are correct except between sample II-5 and the siblings III-1 and III-2. Standard practice is to remove inconsistent samples, in this case sample II-5, resulting in the 5-person pedigree on the right. Panel B shows the true pedigree where sample II-5 was actually the father of the siblings III-1 and III-2 instead of individual II-2, who was not successfully genotyped, being the father. The mix-up could realistically be explained by a sample swap or by misspecified paternity for the two children, and these types of errors are common. Pedigree reconstruction would have revealed the inconsistency and would have easily reconstructed the true pedigree. Therefore, rather than discarding 17% of the data, the investigator could have retained all samples.
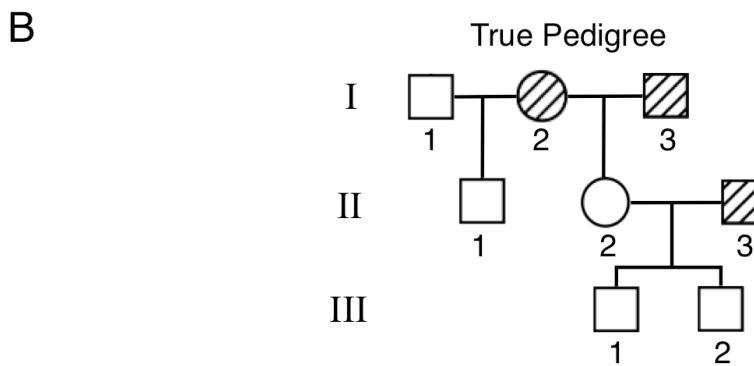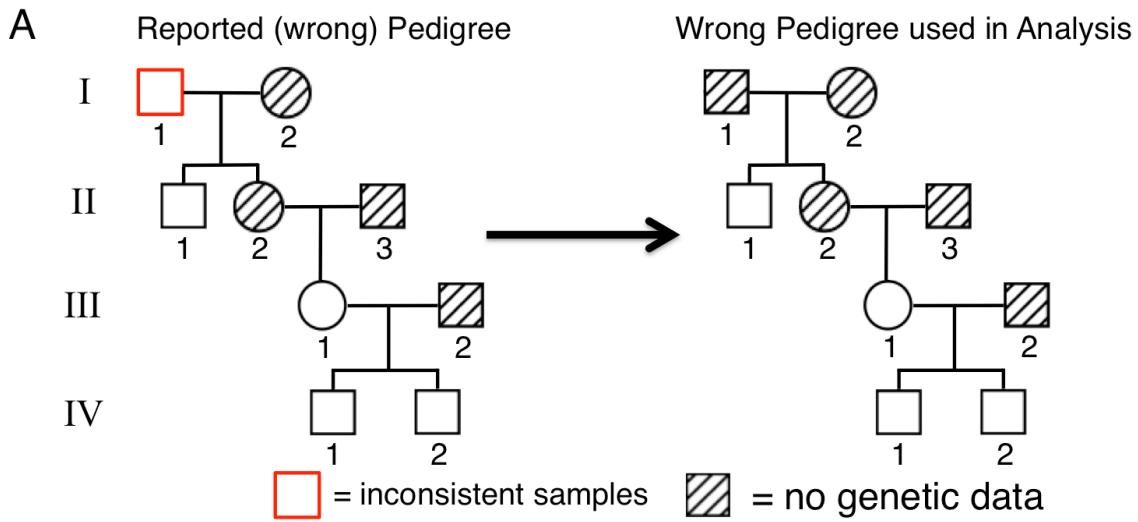
Figure S12. A single example where pairwise relationship checking and removal of an inconsistent sample results in an unnecessary loss of data and the use of an incorrect pedigree. Panel A shows the pedigree as reported by the investigator. Pairwise relationship checking reveals that all relationships are correct except between sample I-1 and samples III-1, IV-1, and IV-2. Standard practice is to remove inconsistent samples, in this case sample I-1, resulting in the 4-person pedigree on the right. Panel B shows the true pedigree. The error in the original pedigree was that sample II-1 was incorrectly assigned as the uncle to sample III-1, when, in fact, they were half-siblings. This mix-up could realistically be explained if the family incorrectly reported their family history or by a clerical error, and these types of errors are common. Pedigree reconstruction would easily have revealed the inconsistency and would have reconstructed the true pedigree. Therefore, rather than discarding 20% of the data and assuming an incorrect pedigree, the investigator would have retained all samples and used the true pedigree in further analyses.

Table S1. True IBD vs. Estimated IBD for different SNP sets

# of SNPs	IBD0 r^2	IBD1 r^2	IB2 r^2
6K	0.987	0.981	0.961
10K	0.992	0.99	0.984
20K	0.995	0.993	0.99
50K	0.997	0.996	0.997
100K	0.997	0.997	0.997
1000K	0.998	0.998	0.997
Linkage Panel IV	0.979	0.974	0.97
Affy 6.0	0.998	0.997	0.993
CytoSNP	0.998	0.997	0.994
HumanCore	0.998	0.997	0.996
Omni Express	0.998	0.998	0.995
Omni 2.5	0.998	0.998	0.995

SNP sets 6K-1000K were generated using PLINK to trim the HapMap3 dataset down to the desired number of SNPs. The remaining SNP sets were generated by taking the intersection of SNPs in those panels and HapMap3. IBD estimates were generated with PLINK using SNPs with a minor allele frequency >1% and a call rate >90%. In statistical package R, we plotted the true IBD proportion to the estimated IBD proportion for each relationship in the 100 halfsib size-20 pedigrees. We then calculated r^2 based on the deviation from Y=X.

Table S2. Combined simulation reconstruction results

Size	structure	0 Missing samples	1 Missing samples	2 Missing samples	3 Missing samples	4 Missing samples	5 Missing samples	6 Missing samples	7 Missing samples	8 Missing samples	9 Missing samples	10 Missing samples
5	highest scoring	200	200	200	NA	NA	NA	NA	NA	NA	NA	NA
5	among highest scoring	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA
5	among scored	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA
5	partially reconstructed	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA
5	missing	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA
10	highest scoring	200	200	195	133	6	0	NA	NA	NA	NA	NA
10	among highest scoring	0	0	5	65	190	20	NA	NA	NA	NA	NA
10	among scored	0	0	0	1	2	4	NA	NA	NA	NA	NA
10	partially reconstructed	0	0	0	0	0	0	NA	NA	NA	NA	NA
10	missing	0	0	0	1	2	0	NA	NA	NA	NA	NA
20	highest scoring	200	200	193	172	138	95	45	13	0	0	0
20	among highest scoring	0	0	6	25	54	94	138	156	131	102	68
20	among scored	0	0	1	3	7	8	12	25	62	72	46
20	partially reconstructed	0	0	0	0	1	1	2	2	3	1	0
20	missing	0	0	0	0	0	2	3	4	4	3	1
30	highest scoring	200	199	197	190	171	148	113	74	47	22	3
30	among highest scoring	0	0	2	8	25	42	69	91	103	102	90
30	among scored	0	0	0	1	2	4	6	14	23	31	40
30	partially reconstructed	0	1	1	1	2	6	11	20	25	43	65
30	missing	0	0	0	0	0	0	1	1	2	2	2
40	highest scoring	198	197	192	189	183	168	150	126	105	78	49
40	among highest scoring	2	2	4	4	9	21	31	44	48	61	65
40	among scored	0	0	0	1	1	1	1	3	8	15	20
40	partially reconstructed	0	1	4	5	6	9	17	24	37	44	62
40	missing	0	0	0	1	1	1	1	3	2	2	4
50	highest scoring	199	197	194	190	186	174	159	141	123	102	84
50	among highest scoring	1	0	2	2	2	8	12	17	24	29	37
50	among scored	0	0	1	0	2	3	6	6	9	9	9
50	partially reconstructed	0	3	3	7	9	13	22	35	42	58	68
50	missing	0	0	0	1	1	2	1	1	2	2	2

We combined the reconstruction results for both the Uniform and Halfsib pedigrees. Some of the Halfsib pedigree structures allowed for more samples to be removed than others due to the random

nature of how they were simulated. As a result, Halfsib size-10 with five missing samples and size-20 with nine and ten missing samples do not add up to 200 simulations. We ran 100 simulations for each size and % of missing samples. For each simulation we determined where the true pedigree fell among the ranked reconstruction results. Each bar displays the proportion of the 100 simulations that corresponded to the five reconstruction outcomes defined as follows:

"highest scoring" – The true pedigree is the highest scoring pedigree

"among highest scoring" – PRIMUS output contained more than one possible pedigree and the true pedigree is tied as the highest scoring pedigree with one or more other pedigrees

"among scored" – the true pedigree is not the highest scoring pedigree, but is among the pedigrees generated by PRIMUS

"partial reconstruction" – the complete reconstruction either resulted in too many possible pedigrees, ran out of memory, or took longer than 36 hours to run and as a result only a partial reconstruction using 1st degree relationships was generated

"missing" – PRIMUS reconstructed one or more possible pedigrees, but the true pedigree was not among them

Table S3. The accuracy of PRIMUS and RELPAIR[5] relationship predictions with Halfsib size-20 pedigrees.

PRIMUS									
Percent Missing samples	0%	5%	10%	15%	20%	25%	30%	35%	40%
1st degree category	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
2nd degree category	100.00%	100.00%	100.00%	100.00%	99.79%	99.63%	99.55%	99.35%	99.55%
3rd degree category	100.00%	100.00%	100.00%	99.79%	98.81%	99.26%	98.30%	96.27%	93.37%
Distantly/unrelated	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
1st degree relationship type	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
2nd degree relationship type	100.00%	100.00%	99.37%	97.12%	96.00%	88.45%	75.61%	66.88%	58.48%
3rd degree relationship type	100.00%	100.00%	98.13%	95.42%	92.46%	85.68%	63.67%	46.73%	26.54%
1st degree relationship type + direction	100.00%	100.00%	100.00%	99.86%	99.84%	99.57%	99.54%	99.52%	99.92%
2nd degree relationship type + direction	100.00%	100.00%	99.41%	97.80%	96.89%	91.18%	80.92%	73.76%	61.95%
3rd degree relationship type + direction	100.00%	100.00%	96.87%	93.37%	91.90%	86.43%	68.29%	45.41%	14.15%
RELPAIR									
Percent Missing samples	0%	5%	10%	15%	20%	25%	30%	35%	40%
1st degree category	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
2nd degree category	99.98%	99.98%	99.97%	99.97%	99.97%	99.96%	100.00%	100.00%	100.00%
3rd degree category	82.72%	82.89%	82.98%	83.13%	83.22%	83.25%	83.32%	83.48%	83.57%
Distantly/unrelated	97.17%	96.67%	96.04%	95.07%	93.75%	91.77%	88.16%	82.52%	66.98%
1st relationship type	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
2nd relationship type	55.95%	55.27%	55.81%	56.18%	56.68%	57.17%	56.20%	57.60%	55.89%
3rd relationship type	NA	NA	NA	NA	NA	NA	NA	NA	NA
1st degree relationship type + direction	NA	NA	NA	NA	NA	NA	NA	NA	NA
2nd degree relationship type + direction	NA	NA	NA	NA	NA	NA	NA	NA	NA
3rd degree relationship type + direction	NA	NA	NA	NA	NA	NA	NA	NA	NA

Halfsib size-20 pedigrees with 0% to 40% missing samples were used to test the pairwise relationship prediction accuracy of both PRIMUS and RELPAIR[5]. We compared the pairwise relationship of the highest ranked pedigree in PRIMUS to the true simulated relationship. We used the method employed by Pemberton et al.[6] to obtain the RELPAIR prediction and then compared that to the true simulated relationship. The table shows accuracy of each method at correctly predicting each relationship in the pedigree by the degree of relatedness (e.g., A and B are first degree relatives), the type of relationship (e.g., A and B have a parental relationship), and the type and directionality of the relationship (e.g., A is the parent of B). The results have been grouped by the degree of the relationships. RELPAIR does not make a distinction between the four 3rd degree relationships nor is it able to predict the directionality of pairwise relationships; therefore, NA is used for those results. The highlighted results are the ones plotted in Figure 2.

Table S4. EOCOPD pedigree reconstruction summary

Fam FID	Reconstructed Correctly	Number of Genotyped Samples	Reconstructed FIDs	Expected Pedigree Rank	Number of Possible Pedigrees	Explanation
Fam1	1	11	1	1	2	
Fam2	1	8	2	1	1	
Fam3	1	13	3	2	2	
Fam4	1	3	4	1	1	
Fam5	1	15	5	1	1	
Fam6	0	9	6	NA	20	NON PATERNITY CAUGHT: half sib is actually full sib
Fam7	1	10	7	20	28	
Fam8	1	9	8	1	1	
Fam9	1	8	9	1	1	
Fam10	1	9	10	1	1	
Fam11	1	4	11	3	7	
Fam12	1	2	12	1	1	
Fam13	1	3	13	1	1	
Fam14	1	5	14	1	1	
Fam15	1	2	15	2	2	
Fam16	1	2	16	1	1	
Fam17	1	8	17	1	1	
Fam18	1	6	18	1	2	
Fam19	1	5	19	32	33	
Fam20	1	15	20	4	11	
Fam21	1	5	21	1	1	
Fam22	1	13	22	1	2	
Fam23	1	8	23	2	3	
Fam24	0	10	24	NA	5	NON PATERNITY CAUGHT: half avuncular instead of avuncular
Fam25	1	5	25	1	1	
Fam26	1	6	26	1	2	
Fam27	1	6	27	1	1	
Fam28	1	14	28	1	1	
Fam29	1	3	29	1	1	
Fam30	1	11	30	1	2	
Fam31	1	5	31	1	1	
Fam32	0	6	32	NA	4	NON PATERNITY CAUGHT

Fam33	1	3	33	1	1	
Fam34	1	4	34	1	4	
Fam35	0	6	35,39	NA	1	Sample missing because of duplicate; Also non-paternity;
Fam36	1	3	36	1	1	
Fam37	1	2	37	2	5	
Fam38	1	3	38	1	1	
Fam39	1	15	39	3	3	Contains duplicate sample
Fam40	1	5	40	1	1	
Fam41	1	6	41	1	3	
Fam42	1	5	42	1	1	
Fam43	1	9	43	4	6	
Fam44	1	14	44	1	2	
Fam45	0	7	45	NA	1	NON PATERNITY CAUGHT
Fam46	1	3	46	1	1	
Fam47	1	6	47	4	4	
Fam48	1	4	48	1	1	
Fam49	1	10	49	1	1	

Table S5. Comparison of HapMap3 pairwise relationships. Each pair of individuals that is predicted to be related in at least one possible pedigree is represented in this table. The table lists the reported relationships from HapMap3, Pemberton et al.[6], Kyriazopoulou-Panagiotopoulou et al.[1] (CARROT), and PRIMUS. The relationships in the PRIMUS column are the aggregate of all relationships from the possible pedigrees, and they are listed as what their relationship is to the other person on the same line. For example, the first row shows that NA19916 is the parent (P) of NA19918, and NA19918 is the offspring (O) of NA19916.

Population	Network	IID1	Sex	Hapmap Reported	PRIMUS Predicted	Pemberton Predicted	CARROT Predicted	IID2	Sex	Hapmap Reported	PRIMUS Predicted	Pemberton Predicted	CARROT Predicted	Notes
ASW	1	NA19916	M	P	P	O,P	-	NA19918	M	O	O	O,P	-	
ASW	1	NA19917	F	P	P	O,P	-	NA19918	M	O	O	O,P	-	
ASW	2	NA19834	M	P	P	O,P	-	NA19836	F	O	O	O,P	-	
ASW	2	NA19835	F	P	P	O,P	-	NA19836	F	O	O	O,P	-	
ASW	3	NA20279	M	-	O	O,P	-	NA20282	F	-	P	O,P	-	
ASW	3	NA20279	M	-	H	H	-	NA20284	M	-	H	H	-	R*
ASW	3	NA20279	M	-	N	N	-	NA20301	F	-	A	A	-	R
ASW	3	NA20279	M	-	1C	-	1C	NA20302	M	-	1C	-	1C	
ASW	3	NA20282	F	P	P	O,P	-	NA20284	M	O	O	O,P	-	
ASW	3	NA20282	F	-	F	F	-	NA20301	F	-	F	F	-	
ASW	3	NA20282	F	-	A	A	-	NA20302	M	-	N	N	-	R*
ASW	3	NA20284	M	-	N	N	-	NA20301	F	-	A	A	-	R
ASW	3	NA20284	M	-	1C	-	1C	NA20302	M	-	1C	-	1C	
ASW	3	NA20301	F	P	P	O,P	-	NA20302	M	O	O	O,P	-	
ASW	4	NA19703	M	P	P	O,P	-	NA19705	M	O	O	O,P	-	
ASW	4	NA19704	F	P	P	O,P	-	NA19705	M	O	O	O,P	-	
ASW	6	NA19900	M	P	P	O,P	-	NA19902	F	O	O	O,P	-	
ASW	6	NA19901	F	P	P	O,P	-	NA19902	F	O	O	O,P	-	
ASW	9	NA20287	F	P	O,P	O,P	-	NA20288	M	O	O,P	O,P	-	
ASW	14	NA19713	F	-	A	A	-	NA19714	F	-	N	N	-	R
ASW	14	NA19713	F	P	P	O,P	-	NA19983	F	O	O	O,P	-	
ASW	14	NA19713	F	-	F	F	-	NA19985	F	-	F	F	-	R
ASW	14	NA19714	F	-	1C	-	1C	NA19983	F	-	1C	-	1C	
ASW	14	NA19714	F	O	O	O,P	-	NA19985	F	P	P	O,P	-	
ASW	14	NA19982	M	P	P	O,P	-	NA19983	F	O	O	O,P	-	
ASW	14	NA19983	F	-	N	N	-	NA19985	F	-	A	A	-	R*
ASW	15	NA20340	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	U	NA20344	F	-	1C,GA,GC,GG,GN,HA,HN,UN	-	U	
ASW	15	NA20340	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA20349	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
ASW	15	NA20344	F	P	P	O,P	-	NA20345	M	O	O	O,P	-	
ASW	15	NA20344	F	-	F	F	-	NA20349	M	-	F	F	-	
ASW	15	NA20344	F	-	A	A	-	NA20350	M	-	N	N	-	R
ASW	15	NA20345	M	-	N	N	-	NA20349	M	-	A	A	-	R*
ASW	15	NA20345	M	-	1C	-	1C	NA20350	M	-	1C	-	1C	
ASW	15	NA20349	M	P	P	O,P	-	NA20350	M	O	O	O,P	-	

ASW	16	NA20281	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA20297	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
ASW	17	NA19908	M	P	P	O,P	-	NA19919	M	O	O	O,P	-	
ASW	17	NA19909	F	P	P	O,P	-	NA19919	M	O	O	O,P	-	
ASW	20	NA19818	M	P	P	O,P	-	NA19828	M	O	O	O,P	-	
ASW	20	NA19819	F	P	P	O,P	-	NA19828	M	O	O	O,P	-	
ASW	29	NA20294	F	P	O,P	O,P	-	NA20295	M	O	O,P	O,P	-	
ASW	30	NA20334	F	P	P	O,P	-	NA20335	M	O	O	O,P	-	
ASW	30	NA20334	F	-	F	F	-	NA20336	F	-	F	F	-	R
ASW	30	NA20334	F	-	A	A	-	NA20337	F	-	N	N	-	R
ASW	30	NA20335	M	-	N	N	-	NA20336	F	-	A	A	-	R
ASW	30	NA20335	M	-	1C	-	1C	NA20337	F	-	1C	-	1C	
ASW	30	NA20336	F	P	P	O,P	-	NA20337	F	O	O	O,P	-	
ASW	44	NA19700	M	P	P	O,P	-	NA19702	M	O	O	O,P	-	
ASW	44	NA19701	F	P	P	O,P	-	NA19702	M	O	O	O,P	-	
ASW	46	NA20289	F	P	P	O,P	-	NA20290	F	O	O	O,P	-	
ASW	46	NA20289	F	-	F	F	-	NA20341	F	-	F	F	-	R
ASW	**46**	**NA20290**	**F**	**-**	**1C,GC,GG,GN,HN,UN**	**-**	**U**	**NA20333**	**F**	**-**	**1C,GA,GC,GG,HA,UN**	**-**	**U**	**P**
ASW	46	NA20290	F	-	N	N	-	NA20341	F	-	A	A	-	R
ASW	46	NA20332	F	P	O,P	O,P	-	NA20333	F	O	O,P	O,P	-	
ASW	**46**	**NA20332**	**F**	**-**	**A,G,H**	**U**	**-**	**NA20343**	**M**	**-**	**C,H,N**	**U**	**-**	**R,P**
ASW	46	NA20332	F	-	1C,UN	-	-	NA20346	M	-	1C,UN	-	-	N
ASW	**46**	**NA20333**	**F**	**-**	**1C,GG,HA,HN**	**-**	**U**	**NA20343**	**M**	**-**	**1C,GC,HA,HN**	**-**	**U**	**P**
ASW	46	NA20342	M	P	P	O,P	-	NA20343	M	O	O	O,P	-	
ASW	**46**	**NA20343**	**M**	**-**	**1C,GC,GG,GN,HN,UN**	**-**	**U**	**NA20346**	**M**	**-**	**1C,GA,GC,GG,HA,UN**	**-**	**U**	**P**
ASW	46	NA20346	M	P	P	O,P	-	NA20347	M	O	O	O,P	-	
ASW	46	NA20347	M	-	1C,GC,GN,HA,HN,UN	-	-	NA20359	F	-	1C,GA,GG,HA,HN,UN	-	-	N
ASW	46	NA20347	M	-	1C,GC,GG,GN,HA,HN,UN	-	-	NA20360	M	-	1C,GA,GC,GG,HA,HN,UN	-	-	N
ASW	46	NA20347	M	-	C,H,N	H	-	NA20363	F	-	A,G,H	H	-	R,?
ASW	46	NA20347	M	-	1C,GC,HA,HN	-	HA	NA20364	F	-	1C,GG,HA,HN	-	HN	?
ASW	46	NA20359	F	P	O,P	O,P	-	NA20360	M	O	O,P	O,P	-	
ASW	46	NA20359	F	-	A,C,G,H,N	A	-	NA20363	F	-	A,C,G,H,N	N	-	R,?
ASW	46	NA20359	F	-	1C,GA,GC,GG,HA,HN,UN	-	GA	NA20364	F	-	1C,GC,GG,GN,HA,HN,UN	-	GN	?
ASW	46	NA20360	M	-	1C,GC,GG,GN,HA,HN,UN	-	1C	NA20363	F	-	1C,GA,GC,GG,HA,HN,UN	-	1C	?
ASW	46	NA20363	F	P	O,P	O,P	-	NA20364	F	O	O,P	O,P	-	
ASW	48	NA20356	M	P	P	O,P	-	NA20358	M	O	O	O,P	-	
ASW	48	NA20357	F	P	P	O,P	-	NA20358	M	O	O	O,P	-	
ASW	49	NA20291	M	P	O,P	O,P	-	NA20292	F	O	O,P	O,P	-	
ASW	62	NA19921	F	P	O,P	O,P	-	NA20129	F	O	O,P	O,P	-	
ASW	65	NA20317	F	P	O,P	O,P	-	NA20319	F	O	O,P	O,P	-	
ASW	71	NA20126	M	P	P	O,P	-	NA20128	F	O	O	O,P	-	
ASW	71	NA20127	F	P	P	O,P	-	NA20128	F	O	O	O,P	-	

ASW	74	NA19914	F	P	O,P	O,P	-	NA19915	M	O	O,P	O,P	-
ASW	80	NA20276	F	P	O,P	O,P	-	NA20277	F	O	O,P	O,P	-
CEU	1	NA10865	M	O	O	O,P	-	NA11891	M	P	P	O,P	-
CEU	1	NA10865	M	O	O	O,P	-	NA11892	F	P	P	O,P	-
CEU	8	NA10836	F	O	O,P	O,P	-	NA12275	F	P	O,P	O,P	-
CEU	12	NA10852	F	O	O,P	O,P	-	NA12045	M	P	O,P	O,P	-
CEU	22	NA10837	M	O	O	O,P	-	NA12272	M	P	P	O,P	-
CEU	22	NA10837	M	O	O	O,P	-	NA12273	F	P	P	O,P	-
CEU	26	NA12766	M	O	O	O,P	-	NA12775	M	P	P	O,P	-
CEU	26	NA12766	M	O	O	O,P	-	NA12776	F	P	P	O,P	-
CEU	27	NA12344	M	O	O	O,P	-	NA12347	M	P	P	O,P	-
CEU	27	NA12344	M	O	O	O,P	-	NA12348	F	P	P	O,P	-
CEU	28	NA12817	M	O	O	O,P	-	NA12827	M	P	P	O,P	-
CEU	28	NA12817	M	O	O	O,P	-	NA12828	F	P	P	O,P	-
CEU	29	NA10840	F	O	O	O,P	-	NA12286	M	P	P	O,P	-
CEU	29	NA10840	F	O	O	O,P	-	NA12287	F	P	P	O,P	-
CEU	32	NA12708	F	O	O,P	O,P	-	NA12718	F	P	O,P	O,P	-
CEU	37	NA06995	M	O	O	O,P	-	NA07037	F	P	P	O,P	-
CEU	37	NA06995	M	O	O	O,P	-	NA07435	M	P	P	O,P	-
CEU	44	NA12375	M	O	O,P	O,P	-	NA12383	F	P	O,P	O,P	-
CEU	46	NA12335	M	O	O	O,P	-	NA12340	M	P	P	O,P	-
CEU	46	NA12335	M	O	O	O,P	-	NA12341	F	P	P	O,P	-
CEU	47	NA12767	F	O	O	O,P	-	NA12777	M	P	P	O,P	-
CEU	47	NA12767	F	O	O	O,P	-	NA12778	F	P	P	O,P	-
CEU	50	NA12877	M	O	O	O,P	-	NA12889	M	P	P	O,P	-
CEU	50	NA12877	M	O	O	O,P	-	NA12890	F	P	P	O,P	-
CEU	52	NA07346	F	P	P	O,P	-	NA07349	M	O	O	O,P	-
CEU	52	NA07347	M	P	P	O,P	-	NA07349	M	O	O	O,P	-
CEU	54	NA12739	M	O	O	O,P	-	NA12748	M	P	P	O,P	-
CEU	54	NA12739	M	O	O	O,P	-	NA12749	F	P	P	O,P	-
CEU	55	NA10864	F	O	O	O,P	-	NA11893	M	P	P	O,P	-
CEU	55	NA10864	F	O	O	O,P	-	NA11894	F	P	P	O,P	-
CEU	59	NA10853	M	O	O,P	O,P	-	NA11843	M	P	O,P	O,P	-
CEU	61	NA12818	F	O	O	O,P	-	NA12829	M	P	P	O,P	-
CEU	61	NA12818	F	O	O	O,P	-	NA12830	F	P	P	O,P	-
CEU	65	NA10843	F	O	O	O,P	-	NA11919	M	P	P	O,P	-
CEU	65	NA10843	F	O	O	O,P	-	NA11920	F	P	P	O,P	-
CEU	66	NA12376	F	O	O	O,P	-	NA12489	F	P	P	O,P	-
CEU	66	NA12376	F	O	O	O,P	-	NA12546	M	P	P	O,P	-
CEU	70	NA12832	F	O	O	O,P	-	NA12842	M	P	P	O,P	-
CEU	70	NA12832	F	O	O	O,P	-	NA12843	F	P	P	O,P	-
CEU	74	NA07014	F	O	O	O,P	-	NA07031	F	P	P	O,P	-
CEU	74	NA07014	F	O	O	O,P	-	NA07051	M	P	P	O,P	-
CEU	77	NA12386	F	O	O	O,P	-	NA12399	M	P	P	O,P	-
CEU	77	NA12386	F	O	O	O,P	-	NA12400	F	P	P	O,P	-

CEU	80	NA12336	F	O	O	O,P	-	NA12342	M	P	P	O,P	-	
CEU	80	NA12336	F	O	O	O,P	-	NA12343	F	P	P	O,P	-	
CEU	82	NA10845	M	O	O	O,P	-	NA11930	M	P	P	O,P	-	
CEU	82	NA10845	M	O	O	O,P	-	NA11931	F	P	P	O,P	-	
CEU	86	NA10847	F	O	O	O,P	-	NA12146	M	P	P	O,P	-	
CEU	86	NA10847	F	O	O	O,P	-	NA12239	F	P	P	O,P	-	
CEU	87	NA10859	F	O	O	O,P	-	NA11881	M	P	P	O,P	-	
CEU	87	NA10859	F	O	O	O,P	-	NA11882	F	P	P	O,P	-	
CEU	89	NA12707	M	O	O,P	O,P	-	NA12716	M	P	O,P	O,P	-	
CEU	90	NA10830	M	O	O,P	O,P	-	NA12154	M	P	O,P	O,P	-	
CEU	91	NA12753	F	O	O	O,P	-	NA12762	M	P	P	O,P	-	
CEU	91	NA12753	F	O	O	O,P	-	NA12763	F	P	P	O,P	-	
CEU	94	NA12865	F	O	O	O,P	-	NA12874	M	P	P	O,P	-	
CEU	94	NA12865	F	O	O	O,P	-	NA12875	F	P	P	O,P	-	
CEU	96	NA10831	F	O	O	O,P	-	NA12155	M	P	P	O,P	-	
CEU	96	NA10831	F	O	O	O,P	-	NA12156	F	P	P	O,P	-	
CEU	106	NA12752	M	O	O	O,P	-	NA12760	M	P	P	O,P	-	
CEU	106	NA12752	M	O	O	O,P	-	NA12761	F	P	P	O,P	-	
CEU	107	NA06985	F	P	P	O,P	-	NA06991	F	O	O	O,P	-	
CEU	107	NA06991	F	O	O	O,P	-	NA06993	M	P	P	O,P	-	
CEU	108	NA10838	M	O	O,P	O,P	-	NA12003	M	P	O,P	O,P	-	
CEU	111	NA06986	M	P	P	O,P	-	NA06997	F	O	O	O,P	-	
CEU	111	NA06997	F	O	O	O,P	-	NA07045	F	P	P	O,P	-	
CEU	111	NA06997	F	-	1C	-	1C	NA12801	M	-	1C	-	1C	
CEU	111	NA06997	F	-	N	N	-	NA12813	F	-	A	A	-	R
CEU	111	NA07045	F	-	A	A	-	NA12801	M	-	N	N	-	R
CEU	111	NA07045	F	-	F	F	-	NA12813	F	-	F	F	-	
CEU	111	NA12801	M	O	O	O,P	-	NA12812	M	P	P	O,P	-	
CEU	111	NA12801	M	O	O	O,P	-	NA12813	F	P	P	O,P	-	
CEU	115	NA10863	F	O	O	O,P	-	NA12234	F	P	P	O,P	-	
CEU	115	NA10863	F	O	O	O,P	-	NA12264	M	P	P	O,P	-	
CEU	117	NA12802	F	O	O	O,P	-	NA12814	M	P	P	O,P	-	
CEU	117	NA12802	F	O	O	O,P	-	NA12815	F	P	P	O,P	-	
CEU	122	NA10846	M	O	O	O,P	-	NA12144	M	P	P	O,P	-	
CEU	122	NA10846	M	O	O	O,P	-	NA12145	F	P	P	O,P	-	
CEU	127	NA10854	F	O	O	O,P	-	NA11839	M	P	P	O,P	-	
CEU	127	NA10854	F	O	O	O,P	-	NA11840	F	P	P	O,P	-	
CEU	131	NA10855	F	O	O	O,P	-	NA11831	M	P	P	O,P	-	
CEU	131	NA10855	F	O	O	O,P	-	NA11832	F	P	P	O,P	-	
CEU	132	NA06994	M	P	P	O,P	-	NA07029	M	O	O	O,P	-	
CEU	132	NA07000	F	P	P	O,P	-	NA07029	M	O	O	O,P	-	
CEU	137	NA12740	F	O	O	O,P	-	NA12750	M	P	P	O,P	-	
CEU	137	NA12740	F	O	O	O,P	-	NA12751	F	P	P	O,P	-	
CEU	139	NA10839	F	O	O	O,P	-	NA12005	M	P	P	O,P	-	
CEU	139	NA10839	F	O	O	O,P	-	NA12006	F	P	P	O,P	-	

CEU	141	NA07345	F	P	P	O,P	-	NA07348	F	O	O	O,P	-	
CEU	141	NA07348	F	O	O	O,P	-	NA07357	M	P	P	O,P	-	
CEU	143	NA12878	F	O	O	O,P	-	NA12891	M	P	P	O,P	-	
CEU	143	NA12878	F	O	O	O,P	-	NA12892	F	P	P	O,P	-	
CEU	147	NA12864	M	O	O	O,P	-	NA12872	M	P	P	O,P	-	
CEU	147	NA12864	M	O	O	O,P	-	NA12873	F	P	P	O,P	-	
CEU	150	NA10856	M	O	O	O,P	-	NA11829	M	P	P	O,P	-	
CEU	150	NA10856	M	O	O	O,P	-	NA11830	F	P	P	O,P	-	
CEU	152	NA10835	M	O	O	O,P	-	NA12248	M	P	P	O,P	-	
CEU	152	NA10835	M	O	O	O,P	-	NA12249	F	P	P	O,P	-	
CEU	156	NA10861	F	O	O	O,P	-	NA11994	M	P	P	O,P	-	
CEU	156	NA10861	F	O	O	O,P	-	NA11995	F	P	P	O,P	-	
CHD	2	NA17981	F	-	F	F	-	NA17986	M	-	F	F	-	R
CHD	16	NA17980	M	-	A,C,G,H,N	U	-	NA18150	F	-	A,C,G,H,N	U	-	R
GIH	54	NA20909	M	-	O,P	U	-	NA20910	F	-	O,P	U	-	R
GIH	61	NA20882	F	-	P	P	-	NA20900	F	-	O	O	-	R
GIH	61	NA20891	M	-	P	P	-	NA20900	F	-	O	O	-	R
GIH	61	NA20891	M	-	A,C,G,H,N	A	-	NA20907	F	-	A,C,G,H,N	N	-	R,?
GIH	61	NA20900	F	-	1C,GC,GN,HA,HN	-	-	NA20907	F	-	1C,GA,GG,HA,HN	-	-	N
GIH	71	NA20874	F	-	F	F	-	NA20879	F	-	F	F	-	R
LWK	3	NA19027	M	-	A,C,G,H,N	U	-	NA19311	M	-	A,C,G,H,N	U	-	R
LWK	13	NA19396	F	-	F	F	-	NA19397	M	-	F	F	-	R
LWK	22	NA19380	M	-	1C,C,GA,GC,GG,HA,HN,N	-	-	NA19381	F	-	1C,A,G,GC,GG,GN,HA,HN	-	-	N
LWK	22	NA19380	M	-	A,C,G,H,N	H	-	NA19382	M	-	A,C,G,H,N	H	-	R,?
LWK	22	NA19381	F	-	O,P	U	-	NA19382	M	-	O,P	U	-	R
LWK	38	NA19347	M	-	F	F	-	NA19352	M	-	F	F	-	R
LWK	45	NA19313	F	-	A,C,G,H,N	U	-	NA19334	M	-	A,C,G,H,N	U	-	R
LWK	60	NA19443	M	-	A	A	-	NA19469	F	-	N	N	-	R
LWK	60	NA19443	M	-	F	F	-	NA19470	F	-	F	F	-	R
LWK	60	NA19469	F	-	O	O	-	NA19470	F	-	P	P	-	R
LWK	69	NA19434	F	-	F	F	-	NA19444	M	-	F	F	-	R
LWK	71	NA19451	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA19452	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
LWK	80	NA19373	M	-	F	F	-	NA19374	M	-	F	F	-	R
LWK	82	NA19309	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA19359	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MEX	0	NA19660	F	P	P	O,P	-	NA19662	F	O	O	O,P	-	
MEX	0	NA19660	F	-	A,C,G,H,N	A	-	NA19664	M	-	A,C,G,H,N	N	-	R,?
MEX	0	NA19660	F	-	1C,GA,GG,HA,HN	-	GA	NA19665	F	-	1C,GC,GN,HA,HN	-	GN	?
MEX	0	NA19660	F	-	P	P	-	NA19685	M	-	O	O	-	R
MEX	0	NA19660	F	-	G	G	-	NA19686	F	-	C	C	-	R
MEX	0	NA19661	M	P	P	O,P	-	NA19662	F	O	O	O,P	-	
MEX	0	NA19661	M	-	P	P	-	NA19685	M	-	O	O	-	R
MEX	0	NA19661	M	-	G	G	-	NA19686	F	-	C	C	-	R

MEX	0	NA19662	F	-	1C,GC,GN,HA,HN	-	1C	NA19664	M	-	1C,GA,GG,HA,HN	-	1C	?
MEX	0	NA19662	F	-	F	F	-	NA19685	M	-	F	F	-	R
MEX	0	NA19662	F	-	A	A	-	NA19686	F	-	N	N	-	R
MEX	0	NA19663	F	P	P	O,P	-	NA19665	F	O	O	O,P	-	
MEX	0	NA19664	M	P	P	O,P	-	NA19665	F	O	O	O,P	-	
MEX	0	NA19664	M	-	1C,GA,GG,HA,HN	-	1C	NA19685	M	-	1C,GC,GN,HA,HN	-	1C	?
MEX	0	NA19684	F	P	P	O,P	-	NA19686	F	O	O	O,P	-	
MEX	0	NA19685	M	P	P	O,P	-	NA19686	F	O	O	O,P	-	
MEX	4	NA19722	F	P	P	O,P	-	NA19724	M	O	O	O,P	-	
MEX	4	NA19723	M	P	P	O,P	-	NA19724	M	O	O	O,P	-	
MEX	5	NA19649	M	P	O,P	O,P	-	NA19650	M	O	O,P	O,P	-	
MEX	6	NA19669	F	P	P	O,P	-	NA19671	F	O	O	O,P	-	
MEX	6	NA19670	M	P	P	O,P	-	NA19671	F	O	O	O,P	-	
MEX	9	NA19657	F	P	P	O,P	-	NA19659	F	O	O	O,P	-	
MEX	9	NA19658	M	P	P	O,P	-	NA19659	F	O	O	O,P	-	
MEX	11	NA19719	F	P	P	O,P	-	NA19721	F	O	O	O,P	-	
MEX	11	NA19720	M	P	P	O,P	-	NA19721	F	O	O	O,P	-	
MEX	16	NA19759	M	P	O,P	O,P	-	NA19760	F	O	O,P	O,P	-	
MEX	20	NA19675	F	P	P	O,P	-	NA19677	F	O	O	O,P	-	
MEX	20	NA19675	F	-	O	O	-	NA19678	F	-	P	P	-	R
MEX	20	NA19675	F	-	O	O	-	NA19679	M	-	P	P	-	R
MEX	20	NA19675	F	-	F	F	-	NA19680	F	-	F	F	-	R
MEX	20	NA19676	M	P	P	O,P	-	NA19677	F	O	O	O,P	-	
MEX	20	NA19677	F	-	C	C	-	NA19678	F	-	G	G	-	R*
MEX	20	NA19677	F	-	C	C	-	NA19679	M	-	G	G	-	R*
MEX	20	NA19677	F	-	N	N	-	NA19680	F	-	A	A	-	R
MEX	20	NA19678	F	P	P	O,P	-	NA19680	F	O	O	O,P	-	
MEX	20	NA19679	M	P	P	O,P	-	NA19680	F	O	O	O,P	-	
MEX	23	NA19651	F	P	P	O,P	-	NA19653	F	O	O	O,P	-	
MEX	23	NA19652	M	P	P	O,P	-	NA19653	F	O	O	O,P	-	
MEX	26	NA19725	F	P	P	O,P	-	NA19727	M	O	O	O,P	-	
MEX	26	NA19726	M	P	P	O,P	-	NA19727	M	O	O	O,P	-	
MEX	28	NA19755	F	P	P	O,P	-	NA19757	M	O	O	O,P	-	
MEX	28	NA19756	M	P	P	O,P	-	NA19757	M	O	O	O,P	-	
MEX	32	NA19773	F	P	P	O,P	-	NA19775	F	O	O	O,P	-	
MEX	32	NA19774	M	P	P	O,P	-	NA19775	F	O	O	O,P	-	
MEX	35	NA19776	F	P	P	O,P	-	NA19778	M	O	O	O,P	-	
MEX	35	NA19777	M	P	P	O,P	-	NA19778	M	O	O	O,P	-	
MEX	38	NA19782	F	P	P	O,P	-	NA19784	M	O	O	O,P	-	
MEX	38	NA19783	M	P	P	O,P	-	NA19784	M	O	O	O,P	-	
MEX	45	NA19779	F	P	P	O,P	-	NA19781	F	O	O	O,P	-	
MEX	45	NA19780	M	P	P	O,P	-	NA19781	F	O	O	O,P	-	
MEX	54	NA19681	F	P	P	O,P	-	NA19683	F	O	O	O,P	-	
MEX	54	NA19682	M	P	P	O,P	-	NA19683	F	O	O	O,P	-	

MEX	55	NA19746	F	P	P	O,P	-	NA19748	F	O	O	O,P	-	
MEX	55	NA19747	M	P	P	O,P	-	NA19748	F	O	O	O,P	-	
MEX	59	NA19716	F	P	O,P	O,P	-	NA19718	F	O	O,P	O,P	-	
MEX	61	NA19794	F	P	P	O,P	-	NA19796	M	O	O	O,P	-	
MEX	61	NA19795	M	P	P	O,P	-	NA19796	M	O	O	O,P	-	
MEX	63	NA19654	F	P	O,P	O,P	-	NA19656	F	O	O,P	O,P	-	
MEX	64	NA19749	F	P	P	O,P	-	NA19751	M	O	O	O,P	-	
MEX	64	NA19750	M	P	P	O,P	-	NA19751	M	O	O	O,P	-	
MEX	67	NA19761	F	P	P	O,P	-	NA19763	F	O	O	O,P	-	
MEX	67	NA19762	M	P	P	O,P	-	NA19763	F	O	O	O,P	-	
MEX	69	NA19770	F	P	P	O,P	-	NA19772	M	O	O	O,P	-	
MEX	69	NA19771	M	P	P	O,P	-	NA19772	M	O	O	O,P	-	
MEX	73	NA19788	F	P	P	O,P	-	NA19790	F	O	O	O,P	-	
MEX	73	NA19789	M	P	P	O,P	-	NA19790	F	O	O	O,P	-	
MKK	8	NA21399	M	P	P	O,P	-	NA21401	M	O	O	O,P	-	
MKK	8	NA21399	M	-	F	F	-	NA21402	M	-	F	F	-	R
MKK	8	NA21399	M	-	A	A	-	NA21404	F	-	N	N	-	R*
MKK	8	NA21399	M	-	F	F	-	NA21405	M	-	F	F	-	R
MKK	8	NA21400	F	P	P	O,P	-	NA21401	M	O	O	O,P	-	
MKK	8	NA21401	M	-	N	N	-	NA21402	M	-	A	A	-	R*
MKK	8	NA21401	M	-	1C	-	-	NA21404	F	-	1C	-	-	N
MKK	8	NA21401	M	-	N	N	-	NA21405	M	-	A	A	-	R
MKK	8	NA21402	M	P	P	O,P	-	NA21404	F	O	O	O,P	-	
MKK	8	NA21402	M	-	F	F	-	NA21405	M	-	F	F	-	R
MKK	8	NA21403	F	P	P	O,P	-	NA21404	F	O	O	O,P	-	
MKK	8	NA21404	F	-	N	N	-	NA21405	M	-	A	A	-	R*
MKK	16	NA21716	M	P	P	O,P	-	NA21718	M	O	O	O,P	-	
MKK	16	NA21716	M	-	A,C,G,H,N	A	-	NA21741	M	-	A,C,G,H,N	N	-	R,?
MKK	16	NA21717	F	P	P	O,P	-	NA21718	M	O	O	O,P	-	
MKK	16	NA21718	M	-	1C,GC,GN,HA,HN	-	-	NA21741	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	25	NA21723	F	-	A,C,G,H,N	H	-	NA21733	F	-	A,C,G,H,N	H	-	R,?
MKK	26	NA21307	M	P	P	O,P	-	NA21309	F	O	O	O,P	-	
MKK	26	NA21307	M	-	A,C,G,H,N	A	-	NA21616	M	-	A,C,G,H,N	N	-	R,?
MKK	26	NA21308	F	P	P	O,P	-	NA21309	F	O	O	O,P	-	
MKK	26	NA21308	F	-	A,C,G,H,N	A	-	NA21379	F	-	A,C,G,H,N	N	-	R,?
MKK	26	NA21308	F	-	A,C,G,H,N	H	-	NA21517	F	-	A,C,G,H,N	H	-	R,?
MKK	26	NA21309	F	-	1C,GC,GN,HA,HN	-	-	NA21379	F	-	1C,GA,GG,HA,HN	-	-	N
MKK	26	NA21309	F	-	1C,GC,GN,HA,HN	-	-	NA21517	F	-	1C,GA,GG,HA,HN	-	-	N
MKK	26	NA21309	F	-	1C,GC,GN,HA,HN	-	-	NA21616	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	26	NA21379	F	-	1C,UN	-	-	NA21517	F	-	1C,UN	-	-	N
MKK	31	NA21357	F	-	F	F	-	NA21509	M	-	F	F	-	R
MKK	40	NA21381	M	P	P	O,P	-	NA21383	M	O	O	O,P	-	
MKK	40	NA21382	F	P	P	O,P	-	NA21383	M	O	O	O,P	-	

MKK	40	NA21382	F	-	1C,GA,GG,HA,HN	-	-	NA21384	M	-	1C,GC,GN,HA,HN	-	-	N
MKK	40	NA21382	F	-	A,C,G,H,N	N	-	NA21387	M	-	A,C,G,H,N	A	-	R,?
MKK	40	NA21382	F	-	1C,GA,GG,HA,HN	-	-	NA21389	M	-	1C,GC,GN,HA,HN	-	-	N
MKK	40	NA21383	M	-	1C,GC,GN,HA,HN	-	-	NA21387	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	40	NA21384	M	P	P	O,P	-	NA21386	F	O	O	O,P	-	
MKK	40	NA21384	M	-	O	O	-	NA21387	M	-	P	P	-	R
MKK	40	NA21384	M	-	O	O	-	NA21388	F	-	P	P	-	R
MKK	40	NA21384	M	-	F	F	-	NA21389	M	-	F	F	-	R
MKK	40	NA21385	F	P	P	O,P	-	NA21386	F	O	O	O,P	-	
MKK	40	NA21386	F	-	C	C	-	NA21387	M	-	G	G	-	R
MKK	40	NA21386	F	-	C	C	-	NA21388	F	-	G	G	-	R
MKK	40	NA21386	F	-	N	N	-	NA21389	M	-	A	A	-	R*
MKK	40	NA21387	M	P	P	O,P	-	NA21389	M	O	O	O,P	-	
MKK	40	NA21388	F	P	P	O,P	-	NA21389	M	O	O	O,P	-	
MKK	43	NA21521	M	-	A,C,G,H,N	U	-	NA21599	M	-	A,C,G,H,N	U	-	R
MKK	43	NA21521	M	-	1C,GA,GG,HA,HN	-	-	NA21601	F	-	1C,GC,GN,HA,HN	-	-	N
MKK	43	NA21599	M	P	P	O,P	-	NA21601	F	O	O	O,P	-	
MKK	43	NA21600	F	P	P	O,P	-	NA21601	F	O	O	O,P	-	
MKK	57	NA21620	F	-	A,C,G,H,N	U	-	NA21719	M	-	A,C,G,H,N	U	-	R
MKK	68	NA21574	F	-	O,P	U	-	NA21575	M	-	O,P	U	-	R
MKK	101	NA21457	F	-	F	F	-	NA21683	F	-	F	F	-	R
MKK	105	NA21363	F	-	O,P	U	-	NA21415	F	-	O,P	U	-	R
MKK	114	NA21440	M	P	P	O,P	-	NA21442	M	O	O	O,P	-	
MKK	114	NA21441	F	P	P	O,P	-	NA21442	M	O	O	O,P	-	
MKK	115	NA21359	M	P	P	O,P	-	NA21361	F	O	O	O,P	-	
MKK	115	NA21360	F	P	P	O,P	-	NA21361	F	O	O	O,P	-	
MKK	119	NA21391	F	-	A,C,G,H,N	H	-	NA21421	F	-	A,C,G,H,N	H	-	R,?
MKK	119	NA21391	F	-	1C,UN	-	-	NA21478	M	-	1C,UN	-	-	N
MKK	119	NA21391	F	-	1C,GA,GC,GG,GN,HA,HN	-	-	NA21485	M	-	1C,GA,GC,GG,GN,HA,HN	-	-	N
MKK	119	NA21391	F	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21488	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	119	NA21421	F	-	1C,UN	-	-	NA21478	M	-	1C,UN	-	-	N
MKK	119	NA21421	F	-	A,C,G,H,N	U	-	NA21485	M	-	A,C,G,H,N	U	-	R
MKK	119	NA21421	F	-	1C,GA,GG,HA,HN	-	-	NA21487	F	-	1C,GC,GN,HA,HN	-	-	N
MKK	119	NA21421	F	-	1C,UN	-	-	NA21488	M	-	1C,UN	-	-	N
MKK	119	NA21475	M	P	P	O,P	-	NA21477	M	O	O	O,P	-	
MKK	119	NA21475	M	-	1C,GC,GN,HA,HN	-	-	NA21478	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	119	NA21475	M	-	1C,GC,GN,HA,HN	-	-	NA21485	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	119	NA21475	M	-	O	O	-	NA21488	M	-	P	P	-	R
MKK	119	NA21475	M	-	O	O	-	NA21489	F	-	P	P	-	R
MKK	119	NA21475	M	-	F	F	-	NA21490	M	-	F	F	-	R
MKK	119	NA21476	F	P	P	O,P	-	NA21477	M	O	O	O,P	-	

MKK	119	NA21477	M	-	C	C	-	NA21488	M	-	G	G	-	R
MKK	119	NA21477	M	-	C	C	-	NA21489	F	-	G	G	-	R
MKK	119	NA21477	M	-	N	N	-	NA21490	M	-	A	A	-	R
MKK	119	NA21478	M	P	P	O,P	-	NA21480	F	O	O	O,P	-	
MKK	119	NA21478	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21485	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	119	NA21478	M	-	GC,UN	-	-	NA21487	F	-	GG,UN	-	-	N
MKK	119	NA21478	M	-	A,C,G,H,N	U	-	NA21488	M	-	A,C,G,H,N	U	-	R
MKK	119	NA21478	M	-	1C,GA,GG,HA,HN	-	-	NA21490	M	-	1C,GC,GN,HA,HN	-	-	N
MKK	119	NA21479	F	P	P	O,P	-	NA21480	F	O	O	O,P	-	
MKK	119	NA21479	F	-	A,C,G,H,N	H	-	NA21685	M	-	A,C,G,H,N	H	-	R,?
MKK	119	NA21480	F	-	1C,GC,GN,HA,HN	-	-	NA21488	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	119	NA21480	F	-	1C,GC,GN,HA,HN	-	-	NA21685	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	119	NA21485	M	P	P	O,P	-	NA21487	F	O	O	O,P	-	
MKK	119	NA21485	M	-	A,C,G,H,N	U	-	NA21488	M	-	A,C,G,H,N	U	-	R
MKK	119	NA21485	M	-	1C,GA,GG,HA,HN	-	-	NA21490	M	-	1C,GC,GN,HA,HN	-	-	N
MKK	119	NA21486	F	P	P	O,P	-	NA21487	F	O	O	O,P	-	
MKK	119	NA21487	F	-	1C,GC,GN,HA,HN	-	-	NA21488	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	119	NA21488	M	P	P	O,P	-	NA21490	M	O	O	O,P	-	
MKK	119	NA21489	F	P	P	O,P	-	NA21490	M	O	O	O,P	-	
MKK	125	NA21352	M	-	A,C,G,H,N	U	-	NA21414	M	-	A,C,G,H,N	U	-	R
MKK	125	NA21352	M	-	1C,GA,GG,HA,HN	-	-	NA21527	M	-	1C,GC,GN,HA,HN	-	-	N
MKK	125	NA21352	M	-	A,C,G,H,N	U	-	NA21583	M	-	A,C,G,H,N	U	-	R
MKK	125	NA21414	M	-	1C,UN	-	-	NA21583	M	-	1C,UN	-	-	N
MKK	125	NA21526	F	P	P	O,P	-	NA21527	M	O	O	O,P	-	
MKK	125	NA21527	M	O	O	O,P	-	NA21583	M	P	P	O,P	-	
MKK	131	NA21300	F	-	1C,GA,GG,HA,HN,UN	-	-	NA21312	M	-	1C,GC,GN,HA,HN,UN	-	-	N
MKK	131	NA21300	F	-	1C,GA,GG,HA,HN,UN	-	-	NA21370	M	-	1C,GC,GN,HA,HN,UN	-	-	N
MKK	131	NA21300	F	-	1C,UN	-	-	NA21435	M	-	1C,UN	-	-	N
MKK	131	NA21300	F	-	A,G,H,N	G	-	NA21520	M	-	A,C,H,N	C	-	R*,?
MKK	131	NA21300	F	-	A,G,H,N	G	-	NA21613	F	-	A,C,H,N	C	-	R,?
MKK	131	NA21300	F	-	A,C,G,H,N	H	-	NA21617	F	-	A,C,G,H,N	H	-	R,?
MKK	131	NA21300	F	-	1C,UN	-	-	NA21647	M	-	1C,UN	-	-	N
MKK	131	NA21300	F	-	1C,UN	-	-	NA21686	F	-	1C,UN	-	-	N
MKK	131	NA21300	F	-	1C,UN	-	-	NA21825	F	-	1C,UN	-	-	N
MKK	131	NA21301	M	P	P	O,P	-	NA21302	F	O	O	O,P	-	
MKK	131	NA21301	M	-	F	F	-	NA21344	M	-	F	F	-	R
MKK	131	NA21301	M	-	A	A	-	NA21366	M	-	N	N	-	R*
MKK	131	NA21302	F	O	O	O,P	-	NA21303	F	P	P	O,P	-	
MKK	131	NA21302	F	-	N	N	-	NA21344	M	-	A	A	-	R*
MKK	131	NA21302	F	-	1C	-	-	NA21366	M	-	1C	-	-	N
MKK	131	NA21311	M	-	G,H	H	-	NA21312	M	-	C,H	H	-	R*,?

MKK	131	NA21311	M	-	GG,HA	-	-	NA21313	M	-	GC,HN	-	-	N
MKK	131	NA21311	M	-	O,P	O	-	NA21314	M	-	O,P	P	-	R,?
MKK	131	NA21311	M	-	G,H	C	-	NA21320	F	-	C,H	G	-	R,?
MKK	131	NA21311	M	-	1C,GC,GG,GN,HA,HN,UN	-	-	NA21367	M	-	1C,GA,GC,GG,HA,HN,UN	-	-	N
MKK	131	NA21311	M	-	1C,UN	-	-	NA21424	F	-	1C,UN	-	-	N
MKK	131	NA21311	M	-	1C,UN	-	-	NA21596	M	-	1C,UN	-	-	N
MKK	131	NA21312	M	P	P	O,P	-	NA21313	M	O	O	O,P	-	
MKK	131	NA21312	M	-	O	O	-	NA21314	M	-	P	P	-	R
MKK	131	NA21312	M	-	G,H	C	-	NA21320	F	-	C,H	G	-	R*,?
MKK	131	NA21312	M	-	1C,GC,GN,HA,HN	-	-	NA21367	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	131	NA21312	M	-	H	U	-	NA21370	M	-	H	U	-	R,P
MKK	131	NA21312	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21423	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21312	M	-	1C,UN	-	-	NA21424	F	-	1C,UN	-	-	N
MKK	131	NA21312	M	-	1C,UN	-	-	NA21447	M	-	1C,UN	-	-	N
MKK	131	NA21312	M	-	1C,GC,GN,HA,HN,UN	-	-	NA21520	M	-	1C,GA,GG,HA,HN,UN	-	-	N
MKK	131	NA21312	M	-	1C,UN	-	-	NA21596	M	-	1C,UN	-	-	N
MKK	131	NA21312	M	-	1C,GC,GN,HA,HN,UN	-	-	NA21613	F	-	1C,GA,GG,HA,HN,UN	-	-	N
MKK	131	NA21312	M	-	C,H,N	U	-	NA21617	F	-	A,G,H	U	-	R,P
MKK	131	NA21313	M	-	C	C	-	NA21314	M	-	G	G	-	R
MKK	131	NA21313	M	-	HA,HN	-	-	NA21320	F	-	HA,HN	-	-	N
MKK	131	NA21313	M	O	O	O,P	-	NA21362	F	P	P	O,P	-	
MKK	131	NA21313	M	-	HN	-	-	NA21370	M	-	HA	-	-	N
MKK	131	NA21313	M	-	1C,GC,GN,HA,HN	-	-	NA21438	F	-	1C,GA,GG,HA,HN	-	-	N
MKK	131	NA21313	M	-	GC,GN,HN	-	-	NA21617	F	-	GA,GG,HA	-	-	N
MKK	131	NA21314	M	-	P	O	-	NA21320	F	-	O	P	-	R
MKK	131	NA21314	M	-	A,C,G,H,N	H	-	NA21367	M	-	A,C,G,H,N	H	-	R,?
MKK	131	NA21314	M	-	1C,UN	-	-	NA21378	M	-	1C,UN	-	-	N
MKK	131	NA21314	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21423	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21314	M	-	1C,UN	-	-	NA21424	F	-	1C,UN	-	-	N
MKK	131	NA21314	M	-	GC,UN	-	-	NA21425	F	-	GG,UN	-	-	N
MKK	131	NA21314	M	-	1C,UN	-	-	NA21447	M	-	1C,UN	-	-	N
MKK	131	NA21314	M	-	1C,UN	-	-	NA21493	F	-	1C,UN	-	-	N
MKK	131	NA21314	M	-	1C,UN	-	-	NA21596	M	-	1C,UN	-	-	N
MKK	131	NA21316	M	P	P	O,P	-	NA21317	M	O	O	O,P	-	
MKK	131	NA21316	M	-	F	F	-	NA21318	M	-	F	F	-	R
MKK	131	NA21316	M	-	A,C,H,N	C	-	NA21519	M	-	A,G,H,N	G	-	R,?
MKK	131	NA21316	M	-	1C,UN	-	-	NA21619	M	-	1C,UN	-	-	N
MKK	131	NA21316	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21635	F	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21316	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21678	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N

MKK	131	NA21317	M	-	N	N	-	NA21318	M	-	A	A	-	R
MKK	131	NA21317	M	-	1C,GC,GN,HN	-	-	NA21519	M	-	1C,GA,GG,HA	-	-	N
MKK	131	NA21317	M	O	O	O,P	-	NA21580	F	P	P	O,P	-	
MKK	131	NA21318	M	-	A,C,H,N	C	-	NA21519	M	-	A,G,H,N	G	-	R,?
MKK	131	NA21318	M	-	1C,UN	-	-	NA21619	M	-	1C,UN	-	-	N
MKK	131	NA21318	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21635	F	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21318	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21678	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21320	F	-	H,N	H	-	NA21365	F	-	A,H	H	-	R,?
MKK	131	NA21320	F	-	1C,HA	-	-	NA21366	M	-	1C,HN	-	-	N
MKK	131	NA21320	F	-	1C,GC,GN,HA,HN	-	-	NA21367	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	131	NA21320	F	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21423	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21320	F	-	1C,UN	-	-	NA21424	F	-	1C,UN	-	-	N
MKK	131	NA21320	F	-	1C,UN	-	-	NA21447	M	-	1C,UN	-	-	N
MKK	131	NA21320	F	-	H,N	H	-	NA21523	M	-	A,H	H	-	R*,?
MKK	131	NA21320	F	-	1C,HA	-	-	NA21525	M	-	1C,HN	-	-	N
MKK	131	NA21320	F	-	1C,UN	-	-	NA21596	M	-	1C,UN	-	-	N
MKK	131	NA21344	M	P	P	O,P	-	NA21366	M	O	O	O,P	-	
MKK	131	NA21362	F	-	A,C,G,H,N	H	-	NA21438	F	-	A,C,G,H,N	H	-	R*,?
MKK	131	NA21362	F	-	1C,GA,GG,HA,HN	-	-	NA21439	M	-	1C,GC,GN,HA,HN	-	-	N
MKK	131	NA21362	F	-	1C,GN,HA,HN,UN	-	-	NA21528	M	-	1C,GA,HA,HN,UN	-	-	N
MKK	131	NA21362	F	-	1C,GN,HA,HN,UN	-	-	NA21587	M	-	1C,GA,HA,HN,UN	-	-	N
MKK	131	NA21365	F	P	P	O,P	-	NA21366	M	O	O	O,P	-	
MKK	131	NA21365	F	-	F	F	-	NA21523	M	-	F	F	-	R
MKK	131	NA21365	F	-	A	A	-	NA21525	M	-	N	N	-	R*
MKK	131	NA21366	M	-	N	N	-	NA21523	M	-	A	A	-	R
MKK	131	NA21366	M	-	1C	-	-	NA21525	M	-	1C	-	-	N
MKK	131	NA21367	M	-	1C,GA,GN,HA,HN,UN	-	-	NA21378	M	-	1C,GA,GN,HA,HN,UN	-	-	N
MKK	131	NA21367	M	-	1C,UN	-	-	NA21423	M	-	1C,UN	-	-	N
MKK	131	NA21367	M	-	1C,UN	-	-	NA21424	F	-	1C,UN	-	-	N
MKK	131	NA21367	M	-	1C,UN	-	-	NA21447	M	-	1C,UN	-	-	N
MKK	131	NA21367	M	-	1C,GA,GN,HA,HN,UN	-	-	NA21493	F	-	1C,GA,GN,HA,HN,UN	-	-	N
MKK	131	NA21367	M	-	1C,GC,UN	-	-	NA21596	M	-	1C,GG,UN	-	-	N
MKK	131	NA21370	M	-	H	H	-	NA21494	F	-	H	H	-	R
MKK	131	NA21370	M	-	1C,GC,GN,HA,HN,UN	-	-	NA21520	M	-	1C,GA,GG,HA,HN,UN	-	-	N
MKK	131	NA21370	M	-	O	O	-	NA21522	M	-	P	P	-	R
MKK	131	NA21370	M	-	1C,GN,HA,HN	-	-	NA21528	M	-	1C,GA,HA,HN	-	-	N
MKK	131	NA21370	M	-	1C,GN,HA,HN	-	-	NA21587	M	-	1C,GA,HA,HN	-	-	N
MKK	131	NA21370	M	-	1C,GC,GN,HA,HN,UN	-	-	NA21613	F	-	1C,GA,GG,HA,HN,UN	-	-	N
MKK	131	NA21370	M	-	C,H,N	U	-	NA21617	F	-	A,G,H	U	-	R,P

MKK	131	NA21370	M	-	C,H	H	-	NA21682	M	-	G,H	H	-	R,?
MKK	131	NA21378	M	-	A,C,H,N	C	-	NA21448	M	-	A,G,H,N	G	-	R,?
MKK	131	NA21378	M	-	A,C,H,N	U	-	NA21453	M	-	A,G,H,N	U	-	R§,P
MKK	131	NA21378	M	-	1C,GA,HA,HN	-	-	NA21455	F	-	1C,GN,HA,HN	-	-	N
MKK	131	NA21378	M	-	F	F	-	NA21493	F	-	F	F	-	R
MKK	131	NA21378	M	-	A	A	-	NA21494	F	-	N	N	-	R*
MKK	131	NA21423	M	P	P	O,P	-	NA21425	F	O	O	O,P	-	
MKK	131	NA21423	M	-	1C,GA,GG,HA,HN	-	-	NA21439	M	-	1C,GC,GN,HA,HN	-	-	N
MKK	131	NA21423	M	-	A,C,G,H,N	A	-	NA21447	M	-	A,C,G,H,N	N	-	R,?
MKK	131	NA21424	F	P	P	O,P	-	NA21425	F	O	O	O,P	-	
MKK	131	NA21424	F	-	F	F	-	NA21596	M	-	F	F	-	R
MKK	131	NA21425	F	-	1C,GC,GN,HA,HN	-	-	NA21447	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	131	NA21425	F	-	N	N	-	NA21596	M	-	A	A	-	R
MKK	131	NA21435	M	-	1C,UN	-	-	NA21520	M	-	1C,UN	-	-	N
MKK	131	NA21435	M	-	1C,UN	-	-	NA21613	F	-	1C,UN	-	-	N
MKK	131	NA21435	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21617	F	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21435	M	-	A,C,G,H,N	U	-	NA21634	M	-	A,C,G,H,N	U	-	R
MKK	131	NA21435	M	-	1C,GA,GG,HA,HN	-	-	NA21636	F	-	1C,GC,GN,HA,HN	-	-	N
MKK	131	NA21435	M	-	1C,A,C,G,GA,GC,GG,GN,H,HA,HN,N	U	-	NA21647	M	-	1C,A,C,G,GA,GC,GG,GN,H,HA,HN,N	U	-	R
MKK	131	NA21435	M	-	1C,GA,GG,HA,HN,U N	-	-	NA21648	M	-	1C,GC,GN,HA,HN,U N	-	-	N
MKK	131	NA21435	M	-	A,C,G,H,N	H	-	NA21825	F	-	A,C,G,H,N	H	-	R,?
MKK	131	NA21438	F	P	P	O,P	-	NA21439	M	O	O	O,P	-	
MKK	131	NA21439	M	O	O	O,P	-	NA21447	M	P	P	O,P	-	
MKK	131	NA21448	M	-	A,C,G,H,N	H	-	NA21453	M	-	A,C,G,H,N	H	-	R,?
MKK	131	NA21448	M	-	1C,GA,GG,HA,HN	-	-	NA21455	F	-	1C,GC,GN,HA,HN	-	-	N
MKK	131	NA21448	M	-	A,G,H,N	G	-	NA21493	F	-	A,C,H,N	C	-	R,?
MKK	131	NA21448	M	-	1C,GA,GG,HA	-	-	NA21494	F	-	1C,GC,GN,HN	-	-	N
MKK	131	NA21453	M	P	P	O,P	-	NA21455	F	O	O	O,P	-	
MKK	131	NA21453	M	-	A,G,H,N	U	-	NA21493	F	-	A,C,H,N	U	-	R§,P
MKK	131	NA21453	M	-	1C,GA,GG,HA	-	-	NA21494	F	-	1C,GC,GN,HN	-	-	N
MKK	131	NA21454	F	P	P	O,P	-	NA21455	F	O	O	O,P	-	
MKK	131	NA21455	F	-	1C,GN,HA,HN	-	-	NA21493	F	-	1C,GA,HA,HN	-	-	N
MKK	131	NA21493	F	P	P	O,P	-	NA21494	F	O	O	O,P	-	
MKK	131	NA21494	F	O	O	O,P	-	NA21522	M	P	P	O,P	-	
MKK	131	NA21494	F	-	1C,GN,HA,HN	-	-	NA21528	M	-	1C,GA,HA,HN	-	-	N
MKK	131	NA21494	F	-	1C,GN,HA,HN	-	-	NA21587	M	-	1C,GA,HA,HN	-	-	N
MKK	131	NA21494	F	-	C,H	H	-	NA21682	M	-	G,H	H	-	R,?
MKK	131	NA21519	M	-	1C,UN	-	-	NA21619	M	-	1C,UN	-	-	N
MKK	131	NA21519	M	-	1C,C,GA,GC,GG,GN,HA,HN,UN	G	-	NA21635	F	-	1C,G,GA,GC,GG,GN,HA,HN,UN	C	-	R,?
MKK	131	NA21519	M	-	GC,HN,U N	-	-	NA21636	F	-	GG,HA,U N	-	-	N

Pop	Num	ID1	Sex1		Genotype1			ID2	Sex2		Genotype2			Result
MKK	131	NA21519	M	-	1C,GA,GC,GG,GN,HA,HN,UN	G	-	NA21678	M	-	1C,GA,GC,GG,GN,HA,HN,UN	C	-	R*,?
MKK	131	NA21520	M	-	F	F	-	NA21613	F	-	F	F	-	R
MKK	131	NA21520	M	-	A,C,H,N	U	-	NA21617	F	-	A,G,H,N	U	-	R§,P
MKK	131	NA21520	M	-	1C,GA,HA,HN	-	-	NA21648	M	-	1C,GN,HA,HN	-	-	N
MKK	131	NA21520	M	-	A,C,H,N	N	-	NA21686	F	-	A,G,H,N	A	-	R,?
MKK	131	NA21520	M	-	1C,UN	-	-	NA21825	F	-	1C,UN	-	-	N
MKK	131	NA21522	M	-	A,G,H,N	H	-	NA21528	M	-	A,C,H,N	H	-	R,?
MKK	131	NA21522	M	-	A,G,H,N	H	-	NA21587	M	-	A,C,H,N	H	-	R*,?
MKK	131	NA21522	M	-	O,P	P	-	NA21682	M	-	O,P	O	-	R,?
MKK	131	NA21523	M	P	P	O,P	-	NA21525	M	O	O	O,P	-	
MKK	131	NA21524	F	P	P	O,P	-	NA21525	M	O	O	O,P	-	
MKK	131	NA21528	M	-	F	F	-	NA21587	M	-	F	F	-	R
MKK	131	NA21528	M	-	1C,GA,GC,HA,HN,UN	-	-	NA21682	M	-	1C,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21587	M	-	1C,GA,GC,HA,HN,UN	-	-	NA21682	M	-	1C,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21613	F	-	A,C,H,N	U	-	NA21617	F	-	A,G,H,N	U	-	R§,P
MKK	131	NA21613	F	-	1C,GA,HA,HN	-	-	NA21648	M	-	1C,GN,HA,HN	-	-	N
MKK	131	NA21613	F	-	A,C,H,N	N	-	NA21686	F	-	A,G,H,N	A	-	R,?
MKK	131	NA21613	F	-	1C,UN	-	-	NA21825	F	-	1C,UN	-	-	N
MKK	131	NA21617	F	-	1C,UN	-	-	NA21647	M	-	1C,UN	-	-	N
MKK	131	NA21617	F	-	1C,UN	-	-	NA21686	F	-	1C,UN	-	-	N
MKK	131	NA21617	F	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	NA21825	F	-	1C,GA,GC,GG,GN,HA,HN,UN	-	-	N
MKK	131	NA21619	M	-	A,C,G,H,N	H	-	NA21635	F	-	A,C,G,H,N	H	-	R*,?
MKK	131	NA21619	M	-	1C,GA,GG,HA,HN	-	-	NA21636	F	-	1C,GC,GN,HA,HN	-	-	N
MKK	131	NA21619	M	-	A,G,GN,H,N	H	-	NA21678	M	-	A,C,GA,H,N	H	-	R,?
MKK	131	NA21634	M	P	P	O,P	-	NA21636	F	O	O	O,P	-	
MKK	131	NA21634	M	-	A,C,G,H,N	U	-	NA21647	M	-	A,C,G,H,N	U	-	R
MKK	131	NA21634	M	-	1C,GA,GG,HA,HN	-	-	NA21648	M	-	1C,GC,GN,HA,HN	-	-	N
MKK	131	NA21634	M	-	1C,UN	-	-	NA21825	F	-	1C,UN	-	-	N
MKK	131	NA21635	F	P	P	O,P	-	NA21636	F	O	O	O,P	-	
MKK	131	NA21635	F	-	F	F	-	NA21678	M	-	F	F	-	R
MKK	131	NA21636	F	-	1C,GC,GN,HA,HN	-	-	NA21647	M	-	1C,GA,GG,HA,HN	-	-	N
MKK	131	NA21636	F	-	N	N	-	NA21678	M	-	A	A	-	R
MKK	131	NA21647	M	P	P	O,P	-	NA21648	M	O	O	O,P	-	
MKK	131	NA21647	M	-	1C,UN	-	-	NA21825	F	-	1C,UN	-	-	N
MKK	131	NA21648	M	O	O	O,P	-	NA21686	F	P	P	O,P	-	
MKK	169	NA21573	M	-	F	F	-	NA21577	M	-	F	F	-	R
YRI	2	NA19184	M	P	P	O,P	-	NA19186	M	O	O	O,P	-	
YRI	2	NA19185	F	P	P	O,P	-	NA19186	M	O	O	O,P	-	
YRI	3	NA19146	M	P	P	O,P	-	NA19148	F	O	O	O,P	-	
YRI	3	NA19147	F	P	P	O,P	-	NA19148	F	O	O	O,P	-	
YRI	11	NA19178	M	P	P	O,P	-	NA19180	F	O	O	O,P	-	

					1C,GA,GC,GG,GN,HA,HN,UN						1C,GA,GC,GG,GN,HA,HN,UN			
YRI	11	NA19178	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	U	NA19200	M	-	1C,GA,GC,GG,GN,HA,HN,UN	-	U	
YRI	11	NA19178	M	-	GC,UN	-	U	NA19202	F	-	GG,UN	-	U	P
YRI	11	NA19179	F	P	P	O,P	-	NA19180	F	O	O	O,P	-	
YRI	11	NA19180	F	-	GG,UN	-	U	NA19200	M	-	GC,UN	-	U	P
YRI	11	NA19200	M	P	P	O,P	-	NA19202	F	O	O	O,P	-	
YRI	11	NA19201	F	P	P	O,P	-	NA19202	F	O	O	O,P	-	
YRI	12	NA18484	F	O	O	O,P	-	NA18486	M	P	P	O,P	-	
YRI	12	NA18484	F	O	O	O,P	-	NA18488	F	P	P	O,P	-	
YRI	15	NA19189	M	P	P	O,P	-	NA19191	M	O	O	O,P	-	
YRI	15	NA19190	F	P	P	O,P	-	NA19191	M	O	O	O,P	-	
YRI	20	NA19113	M	P	P	O,P	-	NA19115	F	O	O	O,P	-	
YRI	20	NA19114	F	P	P	O,P	-	NA19115	F	O	O	O,P	-	
YRI	24	NA19095	F	P	P	O,P	-	NA19097	F	O	O	O,P	-	
YRI	24	NA19096	M	P	P	O,P	-	NA19097	F	O	O	O,P	-	
YRI	26	NA18909	F	P	P	O,P	-	NA18911	M	O	O	O,P	-	
YRI	26	NA18910	M	P	P	O,P	-	NA18911	M	O	O	O,P	-	
YRI	29	NA19247	F	P	P	O,P	-	NA19249	M	O	O	O,P	-	
YRI	29	NA19248	M	P	P	O,P	-	NA19249	M	O	O	O,P	-	
YRI	31	NA18485	M	O	O	O,P	-	NA18487	M	P	P	O,P	-	
YRI	31	NA18485	M	O	O	O,P	-	NA18489	F	P	P	O,P	-	
YRI	32	NA19181	M	P	P	O,P	-	NA19183	F	O	O	O,P	-	
YRI	32	NA19182	F	P	P	O,P	-	NA19183	F	O	O	O,P	-	
YRI	33	NA19256	M	P	P	O,P	-	NA19258	M	O	O	O,P	-	
YRI	33	NA19257	F	P	P	O,P	-	NA19258	M	O	O	O,P	-	
YRI	34	NA19117	M	P	P	O,P	-	NA19174	M	O	O	O,P	-	
YRI	34	NA19118	F	P	P	O,P	-	NA19174	M	O	O	O,P	-	
YRI	38	NA18518	F	O	O	O,P	-	NA18519	M	P	P	O,P	-	
YRI	38	NA18518	F	O	O	O,P	-	NA18520	F	P	P	O,P	-	
YRI	39	NA19213	M	P	P	O,P	-	NA19215	F	O	O	O,P	-	
YRI	39	NA19214	F	P	P	O,P	-	NA19215	F	O	O	O,P	-	
YRI	41	NA19197	F	P	P	O,P	-	NA19199	F	O	O	O,P	-	
YRI	41	NA19198	M	P	P	O,P	-	NA19199	F	O	O	O,P	-	
YRI	46	NA19121	M	P	P	O,P	-	NA19123	M	O	O	O,P	-	
YRI	46	NA19122	F	P	P	O,P	-	NA19123	M	O	O	O,P	-	
YRI	47	NA18916	F	P	P	O,P	-	NA18930	F	O	O	O,P	-	
YRI	47	NA18917	M	P	P	O,P	-	NA18930	F	O	O	O,P	-	
YRI	48	NA18933	F	P	P	O,P	-	NA18935	M	O	O	O,P	-	
YRI	48	NA18934	M	P	P	O,P	-	NA18935	M	O	O	O,P	-	
YRI	49	NA18923	M	P	P	O,P	-	NA18925	M	O	O	O,P	-	
YRI	49	NA18924	F	P	P	O,P	-	NA18925	M	O	O	O,P	-	
YRI	52	NA18497	M	O	O	O,P	-	NA18498	M	P	P	O,P	-	
YRI	52	NA18497	M	O	O	O,P	-	NA18499	F	P	P	O,P	-	
YRI	62	NA18867	F	P	P	O,P	-	NA18869	M	O	O	O,P	-	
YRI	62	NA18868	M	P	P	O,P	-	NA18869	M	O	O	O,P	-	

YRI	65	NA19107	M	P	P	O,P	-	NA19109	F	O	O	O,P	-	
YRI	65	NA19108	F	P	P	O,P	-	NA19109	F	O	O	O,P	-	
YRI	66	NA19235	F	P	P	O,P	-	NA19237	F	O	O	O,P	-	
YRI	66	NA19236	M	P	P	O,P	-	NA19237	F	O	O	O,P	-	
YRI	71	NA19224	M	O	O	O,P	-	NA19225	F	P	P	O,P	-	
YRI	71	NA19224	M	O	O	O,P	-	NA19226	M	P	P	O,P	-	
YRI	81	NA18509	M	O	O,P	O,P	-	NA18511	F	P	O,P	O,P	-	
YRI	83	NA19149	F	P	P	O,P	-	NA19151	F	O	O	O,P	-	
YRI	83	NA19150	M	P	P	O,P	-	NA19151	F	O	O	O,P	-	
YRI	85	NA18873	F	P	P	O,P	-	NA18875	F	O	O	O,P	-	
YRI	85	NA18874	M	P	P	O,P	-	NA18875	F	O	O	O,P	-	
YRI	86	NA18503	M	O	O	O,P	-	NA18504	M	P	P	O,P	-	
YRI	86	NA18503	M	O	O	O,P	-	NA18505	F	P	P	O,P	-	
YRI	91	NA19137	F	P	P	O,P	-	NA19139	M	O	O	O,P	-	
YRI	91	NA19138	M	P	P	O,P	-	NA19139	M	O	O	O,P	-	
YRI	92	NA19152	F	P	P	O,P	-	NA19154	M	O	O	O,P	-	
YRI	92	NA19153	M	P	P	O,P	-	NA19154	M	O	O	O,P	-	
YRI	94	NA19221	F	O	O	O,P	-	NA19222	F	P	P	O,P	-	
YRI	94	NA19221	F	O	O	O,P	-	NA19223	M	P	P	O,P	-	
YRI	95	NA18500	M	O	O,P	O,P	-	NA18501	M	P	O,P	O,P	-	
YRI	105	NA18870	F	P	P	O,P	-	NA18872	M	O	O	O,P	-	
YRI	105	NA18871	M	P	P	O,P	-	NA18872	M	O	O	O,P	-	
YRI	109	NA18861	F	P	P	O,P	-	NA18863	M	O	O	O,P	-	
YRI	109	NA18862	M	P	P	O,P	-	NA18863	M	O	O	O,P	-	
YRI	110	NA18855	F	P	O,P	O,P	-	NA18857	M	O	O,P	O,P	-	
YRI	115	NA19171	M	P	P	O,P	-	NA19173	M	O	O	O,P	-	
YRI	115	NA19172	F	P	P	O,P	-	NA19173	M	O	O	O,P	-	
YRI	117	NA18515	M	O	O	O,P	-	NA18516	M	P	P	O,P	-	
YRI	117	NA18515	M	O	O	O,P	-	NA18517	F	P	P	O,P	-	
YRI	122	NA18912	F	P	P	O,P	-	NA18914	M	O	O	O,P	-	
YRI	122	NA18913	M	P	P	O,P	-	NA18914	M	O	O	O,P	-	
YRI	122	NA18913	M	-	O,P	O,P	-	NA19238	F	-	O,P	O,P	-	
YRI	122	NA18913	M	-	G,H	H	-	NA19240	F	-	C,H	H	-	R,?
YRI	122	NA18914	M	-	C,H	C	-	NA19238	F	-	G,H	G	-	R,?
YRI	122	NA18914	M	-	HA,HN	-	HN	NA19240	F	-	HA,HN	-	HA	?
YRI	122	NA19238	F	P	P	O,P	-	NA19240	F	O	O	O,P	-	
YRI	122	NA19239	M	P	P	O,P	-	NA19240	F	O	O	O,P	-	
YRI	131	NA19209	F	P	P	O,P	-	NA19211	M	O	O	O,P	-	
YRI	131	NA19210	M	P	P	O,P	-	NA19211	M	O	O	O,P	-	
YRI	133	NA18506	M	O	O	O,P	-	NA18507	M	P	P	O,P	-	
YRI	133	NA18506	M	O	O	O,P	-	NA18508	F	P	P	O,P	-	
YRI	134	NA19159	F	P	P	O,P	-	NA19161	M	O	O	O,P	-	
YRI	134	NA19160	M	P	P	O,P	-	NA19161	M	O	O	O,P	-	
YRI	141	NA18858	F	P	P	O,P	-	NA18860	M	O	O	O,P	-	
YRI	141	NA18859	M	P	P	O,P	-	NA18860	M	O	O	O,P	-	

YRI	149	NA19127	F	P	P	O,P	-	NA19129	F	O	O	O,P	-	
YRI	149	NA19128	M	P	P	O,P	-	NA19129	F	O	O	O,P	-	
YRI	150	NA19130	M	P	P	O,P	-	NA19132	F	O	O	O,P	-	
YRI	150	NA19130	M	-	A,C,G,H,N	AV	-	NA19192	M	-	A,C,G,H,N	AV	-	?
YRI	150	NA19130	M	-	1C,GA,GG,HA,HN	-	1C	NA19194	M	-	1C,GC,GN,HA,HN	-	1C	?
YRI	150	NA19131	F	P	P	O,P	-	NA19132	F	O	O	O,P	-	
YRI	150	NA19132	F	-	1C,GC,GN,HA,HN	-	GN	NA19192	M	-	1C,GA,GG,HA,HN	-	GA	?
YRI	150	NA19192	M	P	P	O,P	-	NA19194	M	O	O	O,P	-	
YRI	150	NA19193	F	P	P	O,P	-	NA19194	M	O	O	O,P	-	
YRI	152	NA19116	F	P	P	O,P	-	NA19120	M	O	O	O,P	-	
YRI	152	NA19119	M	P	P	O,P	-	NA19120	M	O	O	O,P	-	
YRI	155	NA19093	F	P	O,P	O,P	-	NA19094	F	O	O,P	O,P	-	
YRI	157	NA18852	F	P	P	O,P	-	NA18854	M	O	O	O,P	-	
YRI	157	NA18853	M	P	P	O,P	-	NA18854	M	O	O	O,P	-	
YRI	160	NA19140	F	P	P	O,P	-	NA19142	M	O	O	O,P	-	
YRI	160	NA19141	M	P	P	O,P	-	NA19142	M	O	O	O,P	-	
YRI	164	NA19206	F	P	P	O,P	-	NA19208	M	O	O	O,P	-	
YRI	164	NA19207	M	P	P	O,P	-	NA19208	M	O	O	O,P	-	
YRI	165	NA19101	M	P	P	O,P	-	NA19103	M	O	O	O,P	-	
YRI	165	NA19102	F	P	P	O,P	-	NA19103	M	O	O	O,P	-	

Notes column codes:

P – PRIMUS provides more precise relationship prediction than other methods.

P* - PRIMUS provides corrected relationship results.

? – One of the other methods reported a more precise relationship prediction than PRIMUS; however, we found several instances where these predictions are incomplete (i.e., the authors failed to recognize that there are more than one possible way to fit the pairwise relationships into a pedigree) or inaccurate.

R – Pemberton et al. prediction was based on RELPAIR results.

R* - The Pemberton et al. reported relationship is based on manually reconstructed pedigrees, and it disagrees with the relationship that RELPAIR predicted.

R§ - Pemberton et al. could not reconcile the predicted 2nd degree relationship with their manually reconstructed pedigree structure.

N – A possible 3rd degree relationship that was unreported in Pemberton et al.[6] and Kyriazopoulou-Panagiotopoulou et al.[1]. However, the MKK population is reported as a small, isolated population, which results in a low level of background relatedness among the samples. The background relatedness can make individuals appear more closely related than they actually are.

Code	Relationship
P	Parent
O	Off-spring
F	Full-sibling
G	Grandparent
C	Grandchild
A	Uncle/Aunt
N	Neice/Nephew
H	Half-sibling
GG	Great-Grandparent
GC	Great-Grandchild
GA	Great-Aunt/Uncle
GN	Great-Neice/Nephew
HA	Half-uncle/aunt
HN	half-neice/nephew
1C	First cousin
U	Uncertain
UN	Unrelated (4th degree or more distant relative)

We used a minimum coefficient of relatedness of 0.09875 (3rd degree relatives or closer) to build the relationship networks for all of HapMap3; however, one family network in the Maasai in Kinyawa, Kenya, (MKK population) contained 126 individuals connected by 3rd degree relationships or closer, and it resulted in a number of possible pedigrees that were computationally infeasible. So, for the MKK population we used a minimum coefficient of relatedness of 0.168 (to include all 2nd degree relatives and closer), resulting in more manageable family network sizes. One MKK family still contained 61 individuals (Network 16 in this table). To reconstruct this network, we broke it into nine sub-networks each containing four to eight closely related samples. We ran PRIMUS on each pair of sub-networks in order to reconstruct relationships between the sub-networks.

Table S6. Possible combinations of pairwise 2nd and 3rd degree family relationships that are considered during reconstruction.

2nd degree relationship between A and B	A	B
1. Half-sib through mother	Half-sib	Half-sib
2. Half-sib through father	Half-sib	Half-sib
3. Avuncular through mother	Nephew	Uncle
4. Avuncular through mother	Uncle	Nephew
5. Avuncular through father	Nephew	Uncle
6. Avuncular through father	Uncle	Nephew
7. Grandparent though father	Grandfather	Grandson
8. Grandparent though father	Grandson	Grandfather
9. Grandparent though mother	Grandfather	Grandson
10. Grandparent though mother	Grandson	Grandfather
3rd degree relationship between A and B	A	B
1. Cousins through A mom and B mom	Cousins	Cousins
2. Cousins through A mom and B dad	Cousins	Cousins
3. Cousins through A dad and B mom	Cousins	Cousins
4. Cousins through A dad and B dad	Cousins	Cousins
5. Great-grandparental through mom's mom	Great-grandfather	Great-grandson
6. Great-grandparental through dad's mom	Great-grandfather	Great-grandson
7. Great-grandparental through mom's dad	Great-grandfather	Great-grandson
8. Great-grandparental through dad's dad	Great-grandfather	Great-grandson

9. Great-grandparental through mom's mom	Great-grandson	Great-grandfather
10. Great-grandparental through dad's mom	Great-grandson	Great-grandfather
11. Great-grandparental through mom's dad	Great-grandson	Great-grandfather
12. Great-grandparental through dad's dad	Great-grandson	Great-grandfather
13. Grand-avuncular through mom's mom	Grand-uncle	Grand-nephew
14. Grand-avuncular through dad's mom	Grand-uncle	Grand-nephew
15. Grand-avuncular through mom's dad	Grand-uncle	Grand-nephew
16. Grand-avuncular through dad's dad	Grand-uncle	Grand-nephew
17. Grand-avuncular through mom's mom	Grand-nephew	Grand-uncle
18. Grand-avuncular through dad's mom	Grand-nephew	Grand-uncle
19. Grand-avuncular through mom's dad	Grand-nephew	Grand-uncle
20. Grand-avuncular through dad's dad	Grand-nephew	Grand-uncle
21. Half-avuncular through mom's mom	Half-uncle	Half-nephew
22. Half-avuncular through dad's mom	Half-uncle	Half-nephew
23. Half-avuncular through mom's dad	Half-uncle	Half-nephew
24. Half-avuncular through dad's dad	Half-uncle	Half -nephew
25. Half-avuncular through mom's mom	Half-nephew	Half-uncle
26. Half-avuncular through dad's mom	Half-nephew	Half-uncle
27. Half-avuncular through mom's dad	Half-nephew	Half-uncle
28. Half-avuncular through dad's dad	Half -nephew	Half-uncle

As the degree of relatedness increases from 2nd to 3rd degree, there are far more relationships to test during reconstruction. Continuing to 4th degree relatives would require testing even more relationships.

Supplemental References
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